ASTRONOMY

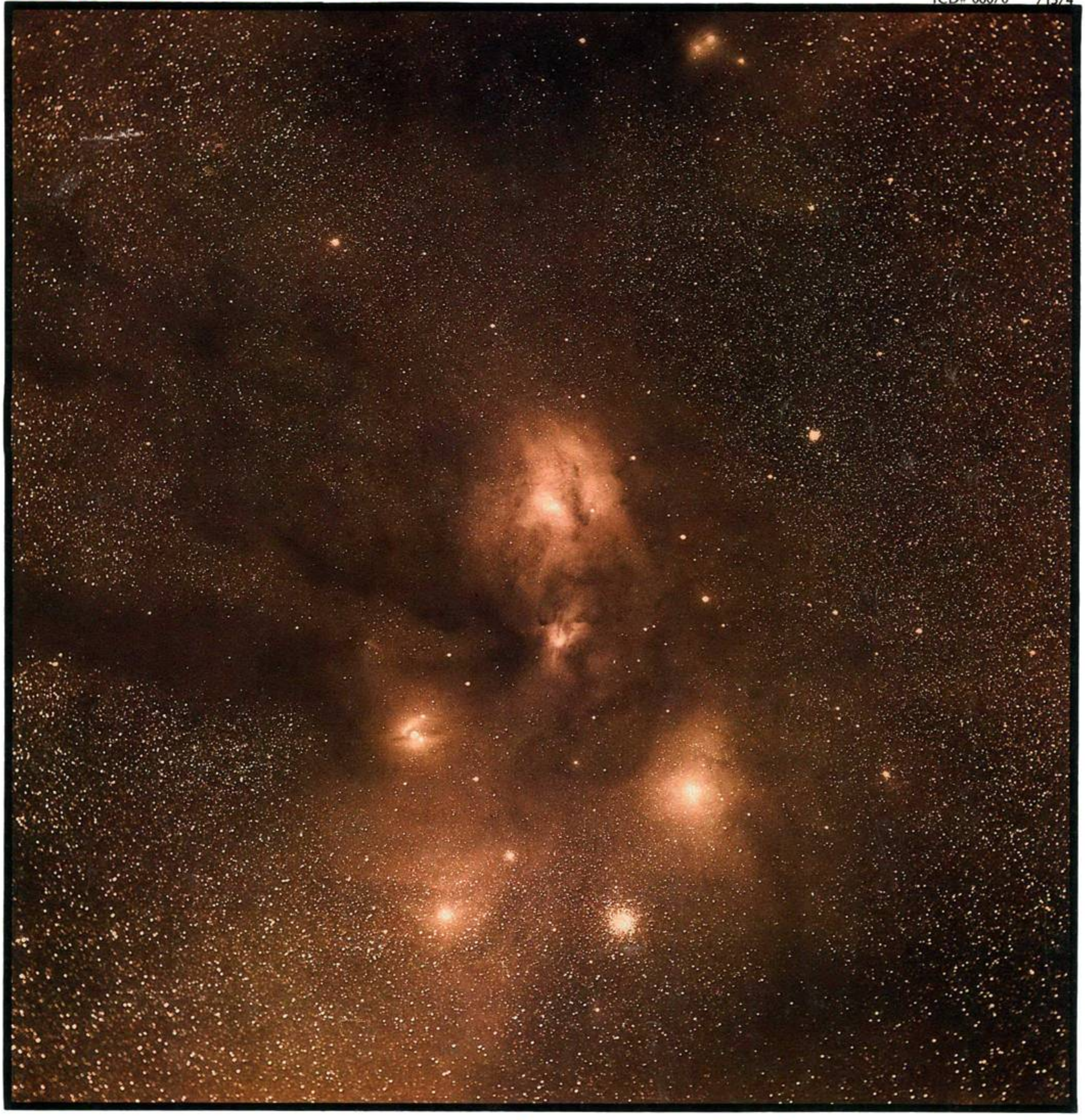
January 1984
U.S. $2
UK £1.15
Can. $2.25

Bart Bok on the Milky Way

Observe the Quadrantid Meteors

Modeling Possible Planets

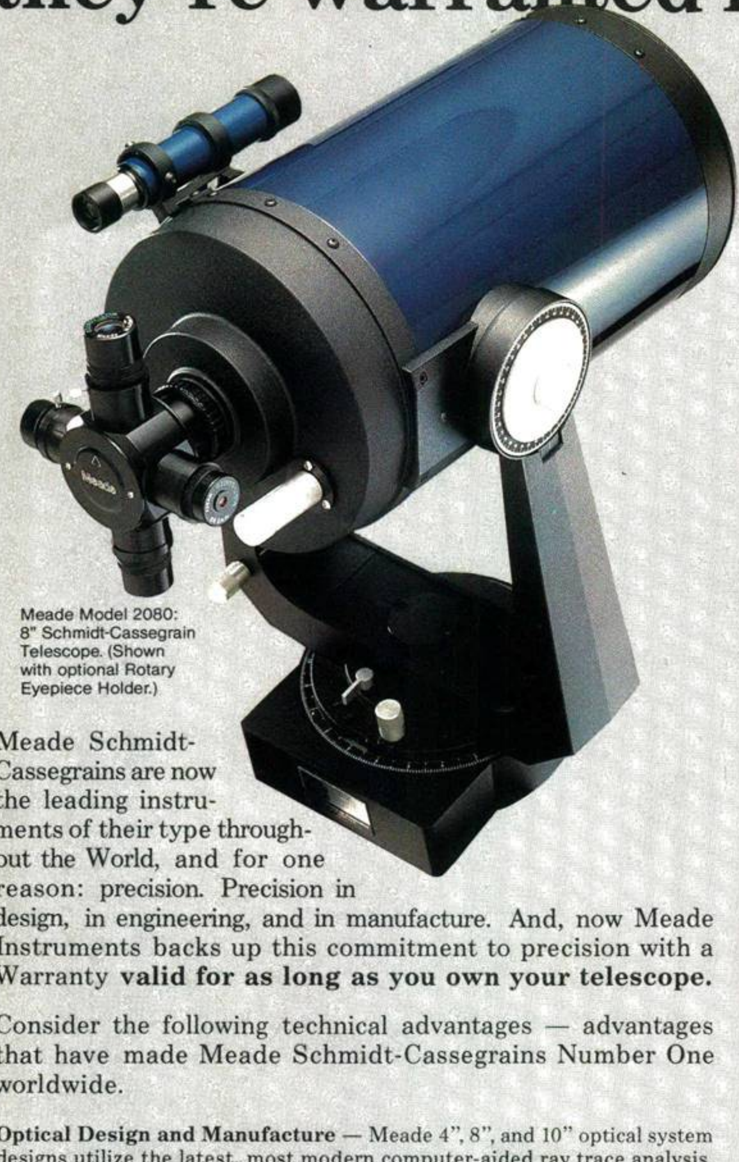
ICD# 08070 71574



The Rho Ophiuchi Dust Complex

0 08070 01
71855

Meade® 4", 8", and 10" Schmidt-Cassegrains: So technically advanced they're warranted for life.



Meade Model 2080: 8" Schmidt-Cassegrain Telescope. (Shown with optional Rotary Eyepiece Holder.)

Meade Schmidt-Cassegrains are now the leading instruments of their type throughout the World, and for one reason: precision. Precision in design, in engineering, and in manufacture. And, now Meade Instruments backs up this commitment to precision with a Warranty **valid for as long as you own your telescope.**

Consider the following technical advantages — advantages that have made Meade Schmidt-Cassegrains Number One worldwide.

Optical Design and Manufacture — Meade 4", 8", and 10" optical system designs utilize the latest, most modern computer-aided ray trace analysis. Analysis which showed us, for example, that by making the primary mirrors of Meade 8" and 10" Schmidt-Cassegrains 3% oversize, we could increase off-axis image brightness by 10% over competing models, aperture for aperture. As a result, the 8" Meade 2080 **without** high transmission coatings yields brighter off-center images than competing 8" telescopes **with** coatings. The 10" Meade 2120 yields off-center images almost as bright as competing 11" models, but with vastly superior portability and at substantially lower cost.

The standard worm-gear drive system of the Meade 8" Model 2080.

Meade diffraction-limited optics are polished to surface accuracies within 1/10-wavelength, and are manufactured and tested with the most precise optical test equipment available. Every 8" system, for example, is tested at 1000X on one of our laser autocollimators and corrected for extremely minute errors in the diffraction image – errors which are invisible to most observers at normal magnifications. Further, each 3-element optical set is **individually** hand-corrected to produce a knife-edge optical null and razor-straight bands under the Ronchi test. This battery of three independent optical tests assures that Meade Schmidt-Cassegrain optics are, without exception, the finest available in any commercial telescope.

Standard-Equipment Worm-Gear Drive Systems — Included with every Meade Schmidt-Cassegrain is the most precise drive system of any instrument in its price and aperture class. The standard drive system of the Meade 8" Model 2080, for example, is now almost legendary among serious amateurs and has been responsible for some of the finest astrophotographs ever produced with amateur-owned equipment.

New LX (Long-Exposure) Drive System now Available on Meade 8" and 10" Schmidt-Cassegrains

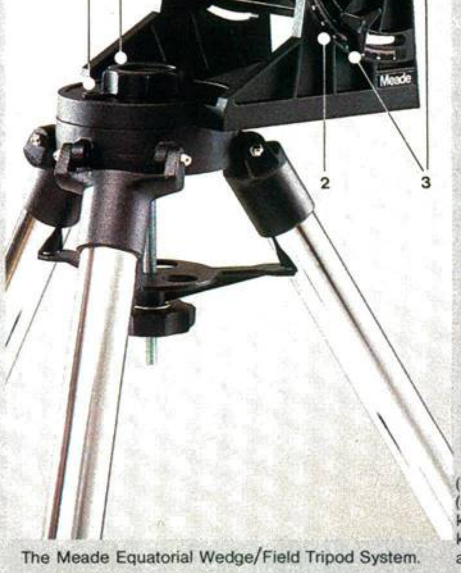
For the most advanced astrophotographic applications, the new Meade LX Drive System is now available optionally at modest additional cost on the 8" Model 2080; the LX Drive System is now included as standard equipment at no additional charge on the Meade 10" Model 2120. The LX Drive includes custom gear components ground with extreme precision, and permits practical long-exposure photographs up to 2 hours' duration. ***The LX Drive System is warranted to equal or exceed the precision of any drive system available on any production Schmidt-Cassegrain telescope.***

Latitude scale of the Equatorial Wedge.

Advanced-Design Equatorial Wedge and Field Tripod Systems — The owner of a Meade Schmidt-Cassegrain will appreciate the attention to detail shown in the Meade Equatorial Wedge and Field Tripod. Each Wedge includes a latitude scale permitting accurate polar alignment of the telescope in a few **seconds,** not minutes. A universal bubble level, machined into the floor of the Wedge and also included as standard equipment, enables the observer to rapidly align the wedge/tripod system to the horizontal, without guesswork. Azimuth orientation is facilitated by the 360°–rotation capability of the Wedge on the Field Tripod — and by the fact that no wrenches or tools of any kind are required in the operation of 4" and 8" models, and only one hex wrench on 10" models.

The Meade Field Tripod, variable in height from 30" to 44", allows comfortable observing in either seated or standing positions, and is almost universally regarded as the strongest, most rigid astronomical tripod yet developed. With its exceptionally low damping time, the Field Tripod is suitable for the most sensitive astrophotographic, as well as visual, applications.

Systems Engineering — Meade Schmidt-Cassegrain telescopes and their long list of related optional accessories were designed as a system of complementary components. The optional electric declination motor,



The Meade Equatorial Wedge/Field Tripod System.

(1) Bubble level; (2) Latitude scale; (3) No-Tool-Required adjustment knobs; (4) Wedge-to-Tripod lock knob, permitting 360° Wedge adjustments in azimuth.

for example, fits neatly in a cavity at the undersurface of one fork arm. Optional dew shields lock into a track pre-machined into the corrector cell of every 8" and 10" telescope. Other accessory systems, from sliding counterweights to the f/2.64 Schmidt Camera, attach directly to the standard telescopes without customer drilling or adaptation. The motivated observer will find an almost unlimited potential for growth, with an absolute minimum of observing time diverted to equipment maintenance and adjustment.

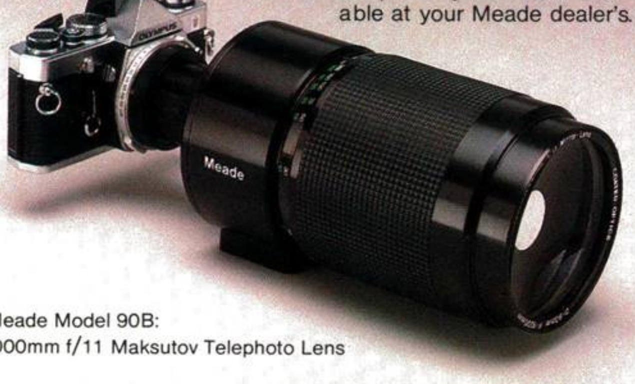
Great Nebula in Orion (M42). A 50-minute exposure on Ektachrome 400 through the Meade 8" Model 2080.

Lifetime Warranty — In the U.S.A. and Canada, Meade 4", 8", and 10" Schmidt-Cassegrain astronomical telescopes are **warranted for life** against defects in materials or manufacture. (Outside North America, see your Meade international distributor for details on his extended-term warranty.) The Meade General Catalog contains full details on this ultimate protection of your investment in astronomy.

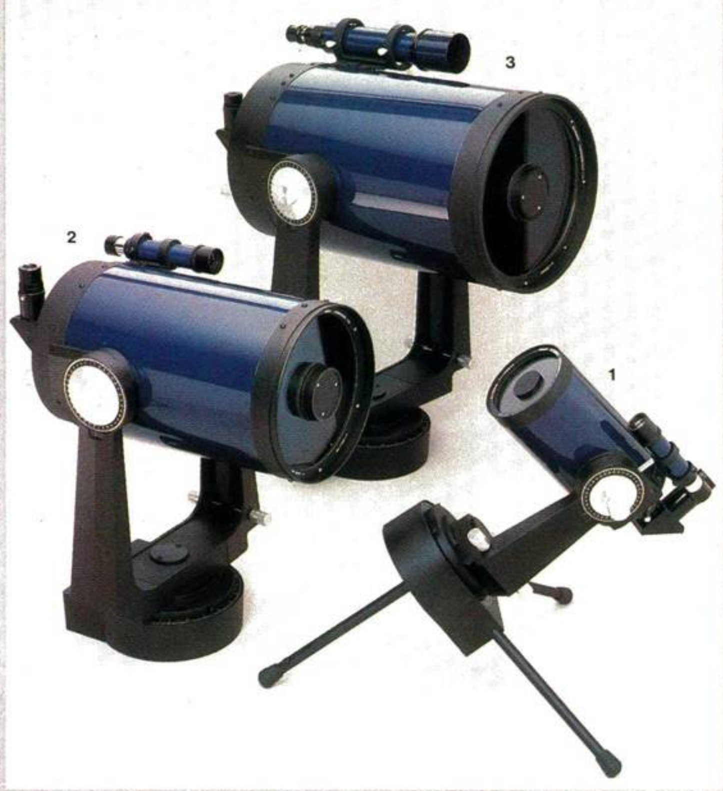
Meade Dealers (hundreds located throughout the U.S.A. and Canada) carry a stock of Meade astronomical telescopes, spotting scopes, telephoto lenses, and accessories, and can offer you further technical information on the wide range of Meade research-quality optical systems — and at surprisingly competitive pricing levels. In the event of a dealer stock shortage on a particular item, we can normally ship to a dealer any Meade Schmidt-Cassegrain complete telescope or accessory within 24 hours.

NEW! MEADE 1000 mm f/11 MAKSUTOV-CASSEGRAIN TELEPHOTO LENSES AND SPOTTING SCOPES

Meade Maksutov telephotos and spotting scopes are manufactured entirely at our Costa Mesa facility. Each model includes a 90mm clear aperture and 1000mm focal length, with all the resolution and performance you'd expect from a Meade optical system. Now available at your Meade dealer's.



Meade Model 90B:
1000mm f/11 Maksutov Telephoto Lens



Meade Schmidt-Cassegrain Telescopes. (1) 4" Model 2044, with standard-equipment table tripod; (2) 8" Model 2080; (3) 10" Model 2120.

Dealer Locations & Assistance

For your nearest Meade dealer location, or for free telescope information and assistance, call Meade Instruments **toll-free** from anywhere in the continental U.S.A. (except Calif.):

1-800-854-7485

From all other areas, including California, dial direct: **(714) 556-2291**

Complete 52-Page General Catalog — $3.00

Send $3.00 for your copy of the all-new Meade full-color **General Catalog #83C,** with many astrophotos through Meade Schmidt-Cassegrains and complete details on the entire range of Meade precision astronomical telescopes, spotting scopes, telephoto lenses, and accessories. Meade General Catalogs are forwarded by return First Class Mail.

AUTHORIZED INTERNATIONAL DISTRIBUTORS

France
Devaux Chevet S.A.
35, Rue de Rivoli
75004 Paris, France

Medas S.A.
57, Avenue Prés. Doumer
B.P. 181
03206 Vichy, France

Switzerland
E. Aeppli/Spiegeloptiken
Loowiesenstrasse 60
CH-8106 Adlikon
Switzerland

Italy
Ottica F.lli Miotti
Piazza Grandi No. 2
20129 Milan, Italy

Japan
MIC International Corp.
Hoshino Bldg.
7-20, Toranomon, 3-chome
Minato-ku, Tokyo, 105 Japan

Taiwan
B & E Optical Co., Ltd.
P.O. Box 84-621
Taipei, Taiwan

Sweden, Denmark, Norway
AB G Wendelholm
Box 14069 S- 10440
Stockholm, Sweden

West Germany, Austria
Kosmos Service
Postfach 640, Pfizerstrasse 5-7
7000 Stuttgart 1
West Germany

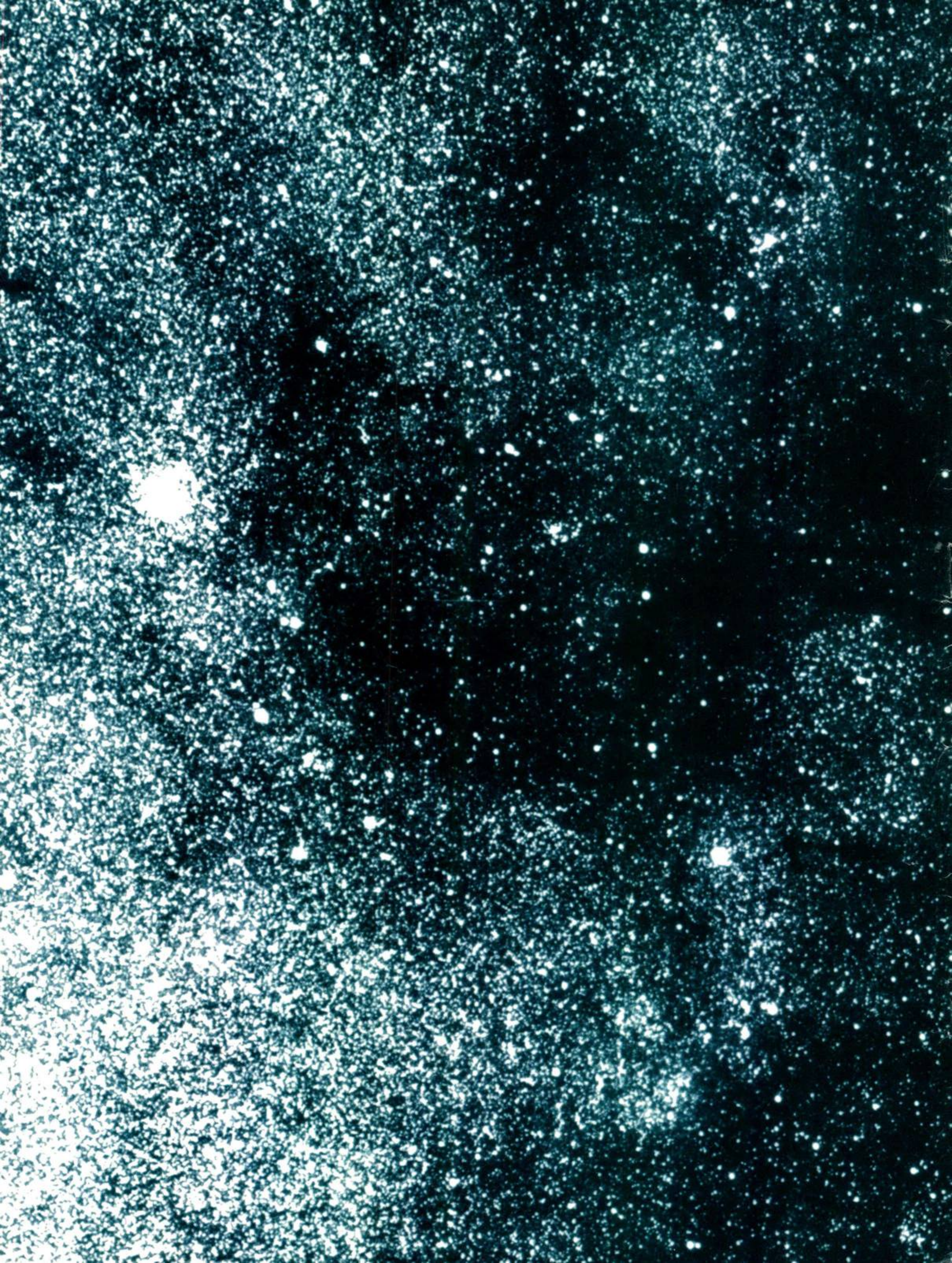
Belgium, Netherlands
O.P.-Slotte
Chaussée D'Alsemberg 59
1060 Brussels, Belgium

Portugal
Contabilex
Av. 25 de Abril, 13-1°
2750 Cascais, Portugal

Australia
Science World
138 Railway Parade
Leederville, 6007,
Perth, Western Australia

Spain
IMVO/R. Roure Codoñer
C/Col. Legi n. 24
(Bordeta) Lleida, Spain

Meade Instruments Corporation
1675 Toronto Way, Costa Mesa, California 92626 ▫ (714) 556-2291



ASTRONOMY

Vol. 12, No. 1

January 1984

The World's Most Beautiful Astronomy Magazine • Established by Stephen A. Walther

Editor-in-Chief
Richard Berry
Managing Editor
Katherine Bond
Art Director
Thomas L. Hunt
Associate Editor
Robert Burnham
Assistant Editors
David J. Eicher
Francis Reddy
Production Assistants
Jane B. Lucius
Mary MacAdam
Editorial Assistant
Mary Algozin

President, AstroMedia Corp.
Robert A. Maas
Advertising Coordinator
Dana-Lynne Terry
Comptroller
Dennis K. Wilk
Product Manager
Susan Poole
Circulation Director
Kristie Fischer
Circulation Manager
Rosemary L. Pickart

Adv. Rep., NE Region
Adpress, Inc.
New York, NY 10016
(212) 679-1710
U.S. Newsstand Distribution
I.C.D., The Hearst Corp.
New York, NY 10019
Canadian Newsstand Dist.
Distr. Div. of TV GUIDE
Toronto, Ontario M4S 3B3
World Newsstand Distribution
Boarts International, Inc.
New York, NY 10019

6 **A Bigger and Better Milky Way Galaxy**
by Bart J. Bok

Forum 24 **In Search of the Magellanic Clouds and Other Southern Delights**
100 Years at Chabot Observatory

In Focus 32

Behind the Scenes 33

Photography in Astronomy 35 **Add Drama and Interest to Your Astrophotos**
by Kevin Moan

Astronomy Reviews 39

Eye on the Sky 42 **Planetary Alignment Opens the Year**
by Fred Schaaf

Equipment Atlas 51 **Clocks and Calendars for Astronomy**
by Sethanne Howard

AstroNews 60

AstroMart 65

Stellar Frontiers 66 **Possible Planets, Part I**
by Stephen L. Gillett

Gazer's Gazette 75 **Prepare for the Quadrantids!**
by Terry Schmidt

The Backyard Astronomer 78 **Perseus**

Cover: The region around Antares and Rho Ophiuchi is one of the richest areas of the Milky Way; this photograph by pioneer astrophotographer E.E. Barnard shows it cluttered with star clusters, dark nebulae, gas reflecting starlight, and thousands of stars. This month, ASTRONOMY brings you up to date on our Milky Way Galaxy and what astronomers have recently learned about it, as told by the late Bart Bok. These pages: The Scutum Starcloud, photographed by Barnard.

ASTRONOMY (ISSN 0091-6358) is published monthly by AstroMedia Corp., 625 E. St. Paul Ave., P.O. Box 92788, Milwaukee, WI 53202. Copyright © 1983 AstroMedia Corp., all rights reserved. Material in this publication may not be reproduced in any form without permission. Second class postage paid at Milwaukee, WI and additional mailing offices. POSTMASTER: Send address changes to ASTRONOMY, P.O. Box 92788, Milwaukee, WI 53202. Questions about subscriptions and product orders: (414) 276-8547 weekdays, 8am - 4pm. Allow six to eight weeks for new subscriptions and changes of address. New subscriptions start with current issue. Subscription price: 1 year, $21.00. All foreign: add $5.00 per year; please remit in U.S. funds. Send editorial and business inquiries and submissions to the address above. Telephone: (414) 276-2689. Not responsible for unsolicited materials. AstroMedia staff: Patricia Adams, Jacquelyn Berger, Tony Cunning, Merlene Edwards, Wendy Graika, Rosemarie Kearns, Maggie Martinez, Rose McVeigh, Sherrie Miller, Susan Robinson, Deborah Weinstein. ASTRONOMY is indexed in *The Reader's Guide to Periodical Literature*. Microfilms of ASTRONOMY available from University Microfilms, Inc., 300 N. Zeeb Rd., Ann Arbor, MI 48106 and Bell & Howell Company, Old Mansfield Rd., Wooster, OH 46691. Printed in the U.S.A.

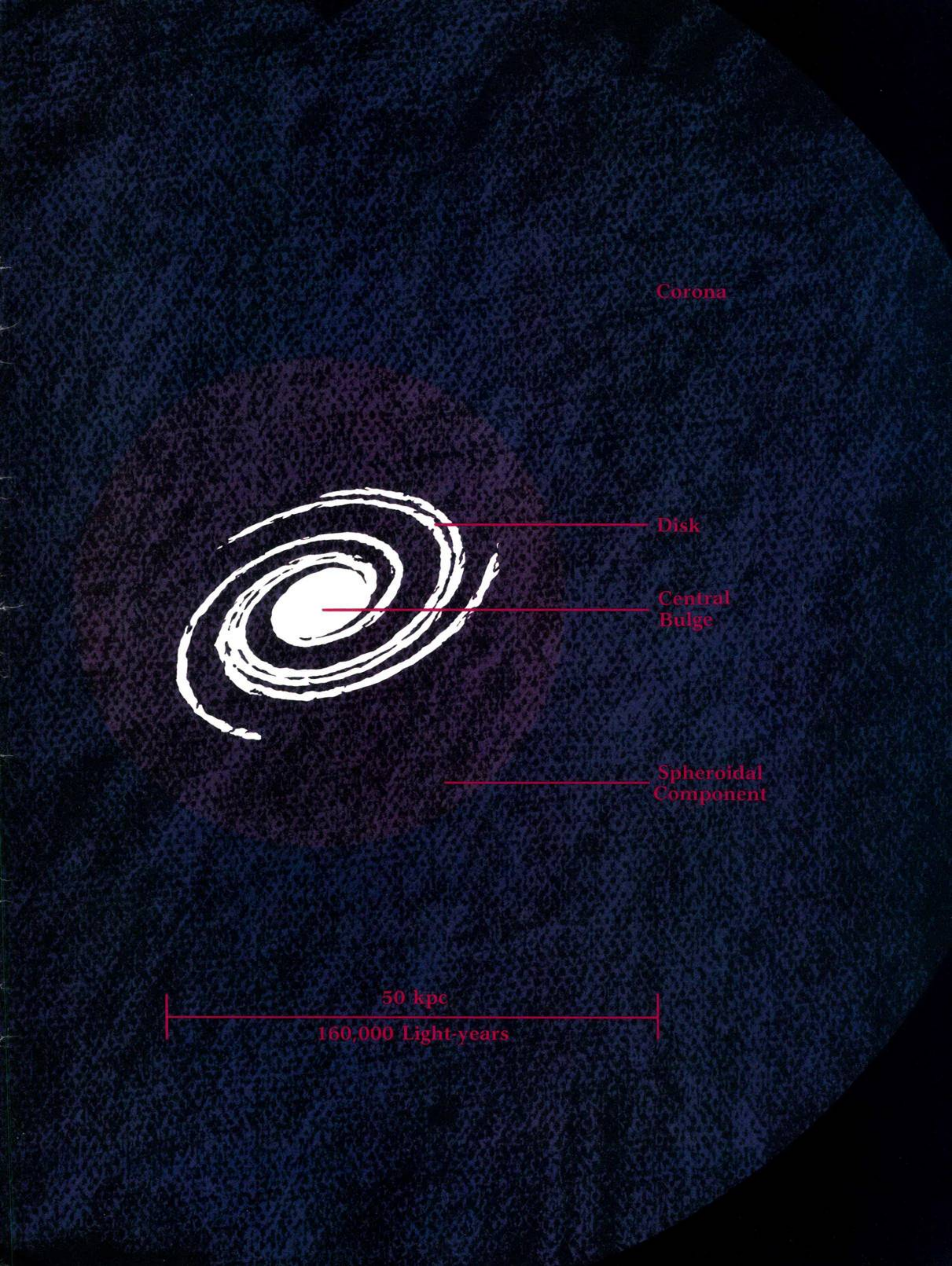
A Bigger & Better Milky Way Galaxy

by Bart Bok

The New Galaxy

Due to new research techniques, our picture of the Milky Way Galaxy has changed dramatically during the past few years. In 1973, the maximum radius of the Galaxy was about 20 kiloparsecs. The new radius is at least three times — and possibly five times — the earlier value. Whereas the mass of our 1973 Galaxy was 100 to 200 billion solar masses, newer evidence from the large rotational motions of galactic gas clouds and the motions of a dozen or so outlying globular clusters indicate a total mass of at least 600 billion solar masses, possibly even 1 to 2 *trillion* solar masses.

We now recognize four major parts of our Galaxy: the *central bulge*, a flattened and spheroidal nucleus perhaps centered upon a black hole; the thin *disk* component, which contains stars, interstellar dust and gas, and the Sun and Earth; the *spheroidal component*, formerly called the halo, which extends 25 kiloparsecs from the center and contains old stars; and the tenuous but very large (hence very massive), newly discovered *corona*, apparently *not* populated by stars, but the home of the "missing mass" of our Galaxy; its minimum radius is 60 kiloparsecs.


Corona
Disk
Central Bulge
Spheroidal Component
50 kpc
160,000 Light-years

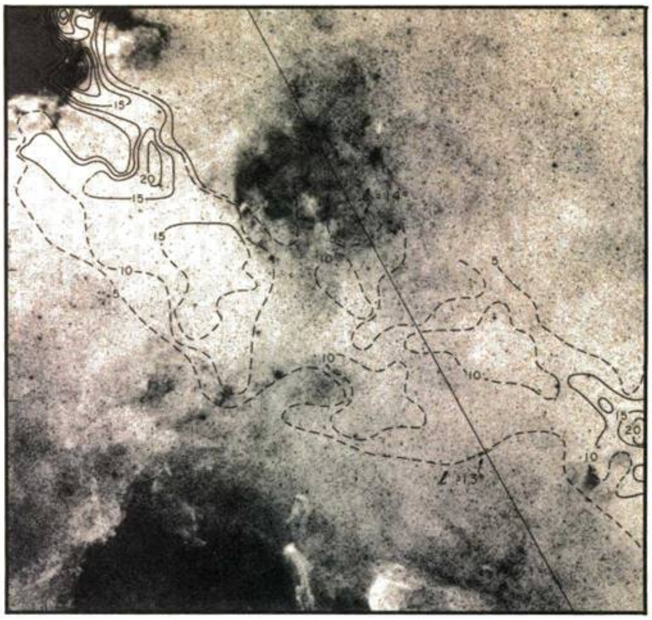
A decade ago, our knowledge of the structure, dimensions, and motions in the Milky Way system – our Home Galaxy — seemed reasonably complete. We believed that our Galaxy was an average spiral with a dense, starry nucleus and an extended halo thinly populated with old stars. The nuclear region measured about 5,000 parsecs across and was slightly flattened. The disk portion had an outer radius of about 12,000 parsecs and, for the most common varieties of stars, had an effective thickness of only 1,000 parsecs. However, this thickness was only one-third as great for the gas and cosmic dust scattered throughout the disk. The all-enveloping halo was a slightly flattened sphere with a maximum radius of a little over 15,000 parsecs.

Our Galaxy, we thought, was rotating at a rate of 220 kilometers per second at the position of the solar system, which lay in the central plane of the disk, some 8,500 parsecs out from the center. The age of our Galaxy — that is, the time since its formation — was estimated to be some 15 billion years, or about three times the age of the solar system. The total mass of our "1973 Galaxy" was well under 200 billion solar masses.

But our laboriously acquired image of the Galaxy began to change about 1973. Jeremiah Ostriker, P.J.E. Peebles, and Amos Yahil of Princeton and Jan Einasto of Estonia suggested that the familiar Galaxy we just described is embedded in an enormous low-density *corona* that extends at least 60,000 parsecs and possibly 100,000 parsecs from its center. This vast corona, though very tenuous, contains enough material to raise the total mass of our Galaxy to at least 600 billion, and possibly as much as 2 trillion solar masses. Our old Galaxy is only a small part of a Bigger and Better Galaxy.

The evidence for this Bigger and Better Galaxy is mainly theoretical. Einasto, for example, has argued that the Andromeda Galaxy is sufficiently pulled on by our Galaxy so that it is falling toward us at an observed rate of 300 kilometers per second — and this requires that our Galaxy have a mass of more than one trillion solar masses. Another problem is that dynamical studies show our 1973 Galaxy cannot hold itself together unless it is embedded in the additional mass of an outer corona.

Why did we have to wait until now for observational evidence for the big and massive Galaxy? Until recently, we astronomers had too little good data. In the 1930s many of us tried to push beyond the observational limits set by what now seem to be primitive and inefficient fact-gathering techniques. The 1920s and 1930s were the years when studies of stellar distribution using the Kapteyn Selected Areas — regions of sky chosen by the Dutch astronomer Jacobus Kapteyn for star counting — were in vogue. At Yerkes Observatory, William Morgan and Philip Keenan developed the MK system of spectral classification (the one currently used for classifying stars), and the transition from photographic to photoelectric photometry had just begun. Just before World War II, the automation of data gathering began developing along with computer techniques, but progress was slow. Photoelectric photometry was coming of age, but the big push didn't happen until the 1950s, when it became the accepted tool.

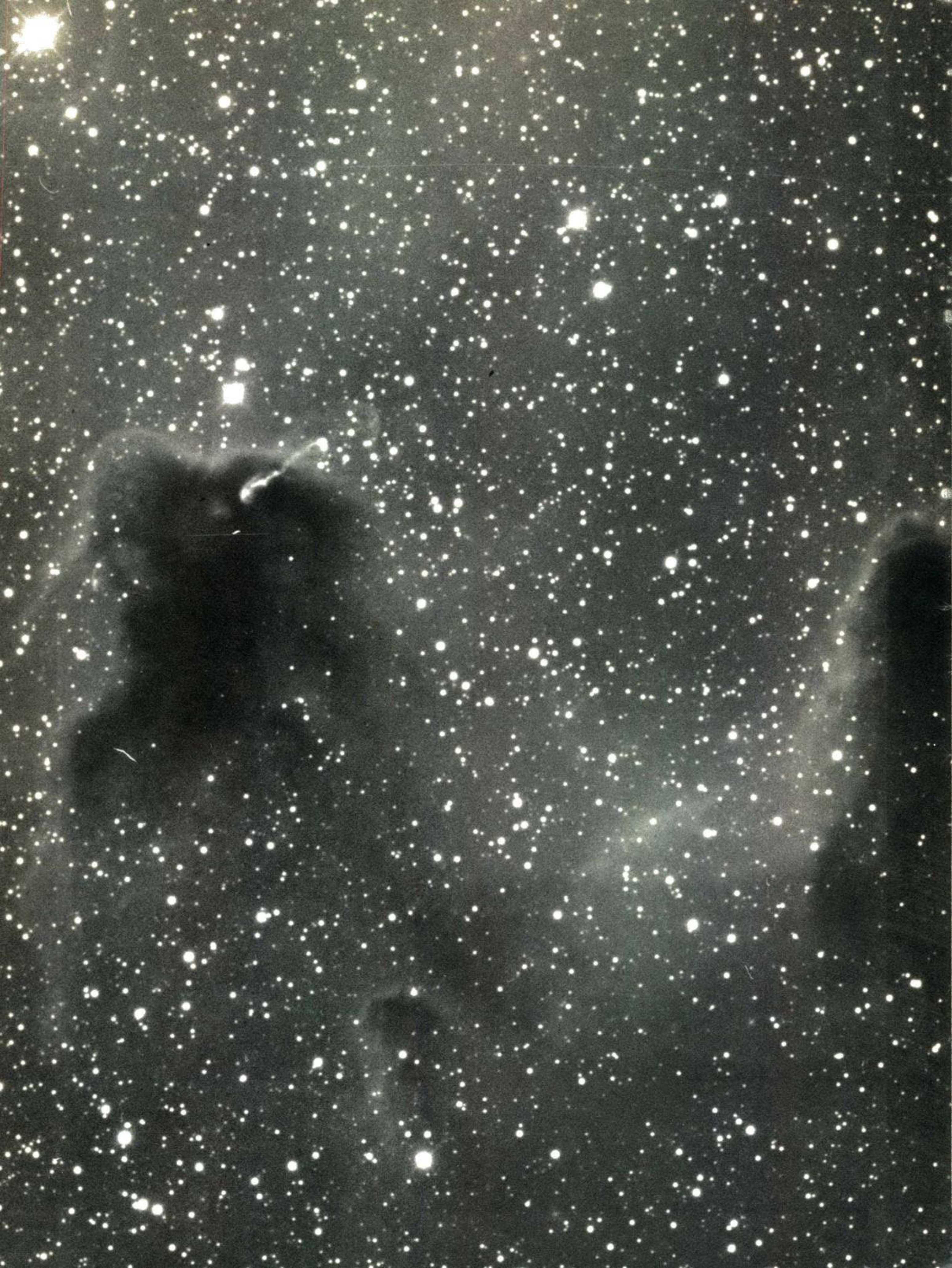


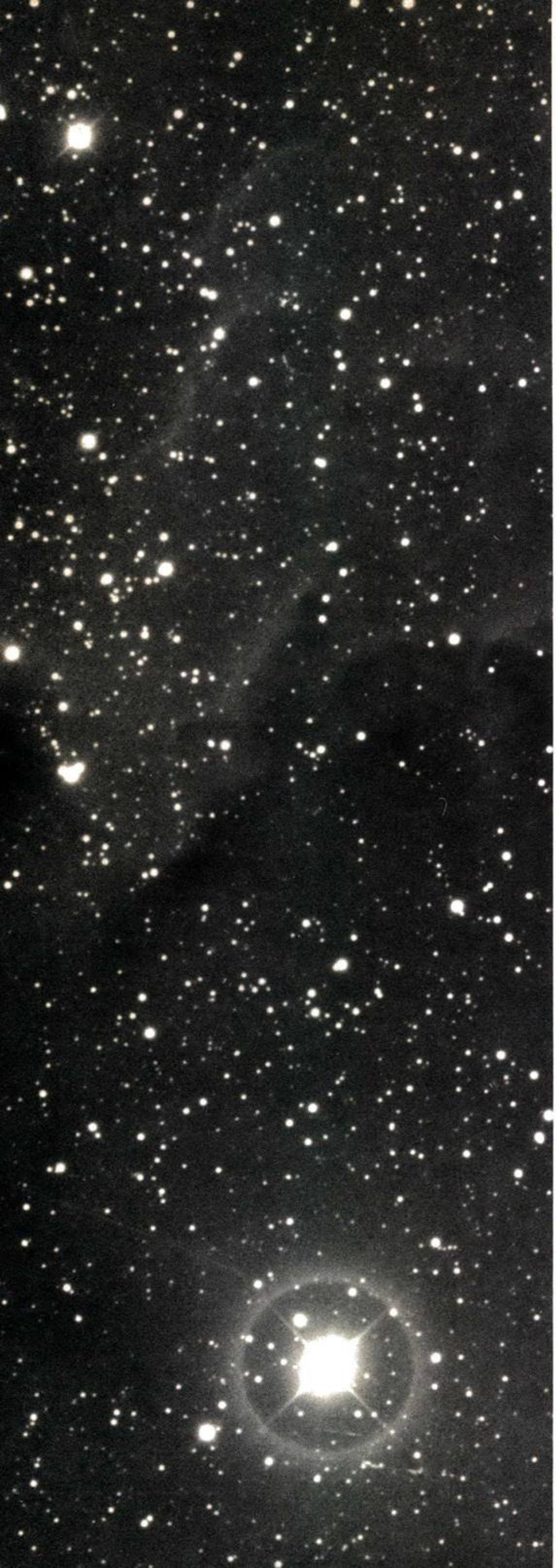
Left: With shock fronts created by stellar winds, stars of the Lagoon Nebula (M-8) ionize hydrogen and form young stars — one of the methods of starbirth in the Galaxy. Kitt Peak 4-meter photo. Above: This radio map shows CO outflow from a GMC complex near M-17. Courtesy Charles Lada, University of Arizona.

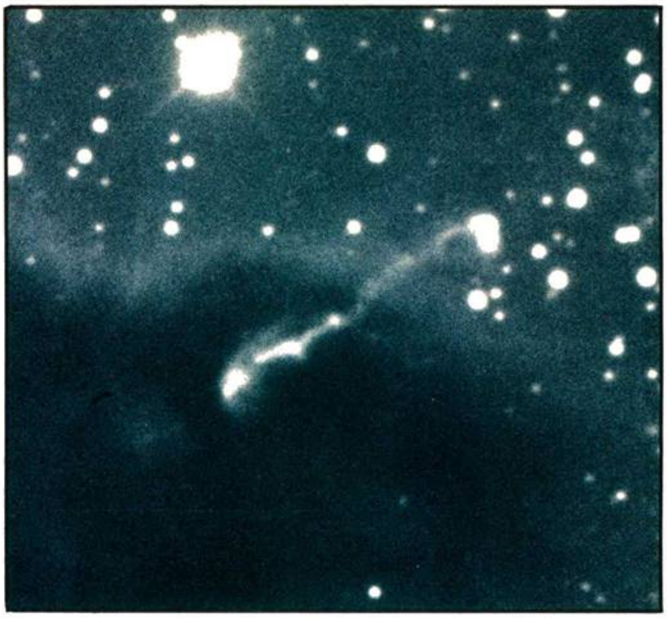
Much-needed fundamental star positions and high-quality proper motions (measurements of stars' angular motions with respect to each other) became available, as well as trigonometric parallaxes of faint stars and a rapidly increasing supply of radial velocities — measurements of stellar motions along our line of sight. Studies of variable stars flourished. Our knowledge of globular clusters advanced steadily with beautiful basic studies of the colors and magnitudes of the stars they contain. Moreover, radio astronomy was becoming a powerful new discipline. The discovery of the 21-centimeter line of atomic hydrogen, which allowed easy radio detection of neutral hydrogen, opened up wholly new approaches for Milky Way researchers. Even back in the 1930s, we could see that automation and computer techniques held terrific promise for gathering the vast body of basic data that we needed for the proper study of our Galaxy.

The strongest evidence for the inner parts of the Galaxy's vast corona comes from observations of the Milky Way's motions. The outer parts of our Galaxy rotate much faster than expected. In the middle 1960s and early 1970s, we had generally assumed that the rotation speed of our Galaxy would drop gradually, in Keplerian fashion, for distances beyond 10,000 parsecs from the galactic center. By 1980, evidence from the velocities of newly discovered interstellar clouds had destroyed the old model; the velocity of rotation for areas between 10,000 and 20,000 parsecs out from our Galaxy's center *rose* from 220 kilometers per second to close to 300 kilometers per second.

This new result indicates that the halo of our Galaxy, the outer part of which we now call the corona, is a massive affair, extending to at least 25,000 parsecs from the center of the Galaxy. The first indications for the presence of a massive, invisible outer component in spiral galaxies like our own came from radio studies of some of our neighbors — M-31, M-81, and M-101 — suggesting that not only our own Galaxy but its neighbors have coronas that stretch far beyond the observed limits of their spectacular spiral structure. It is not surprising that astronomers now expend much effort on the rotation curve — the plot of rotation speeds versus distance from the center — for our own Galaxy. The basic data have







Left: A globule in the constellation Vela showing a luminous edge crosscut by an "umbilical cord" that connects two Herbig-Haro objects. The objects were apparently shot out of the globule by still-forming protostars. Above: Detail of the Vela globule. Cerro Tololo 4-meter photos by Bart J. Bok.

come from optical observations of HII regions and open clusters and radio studies.

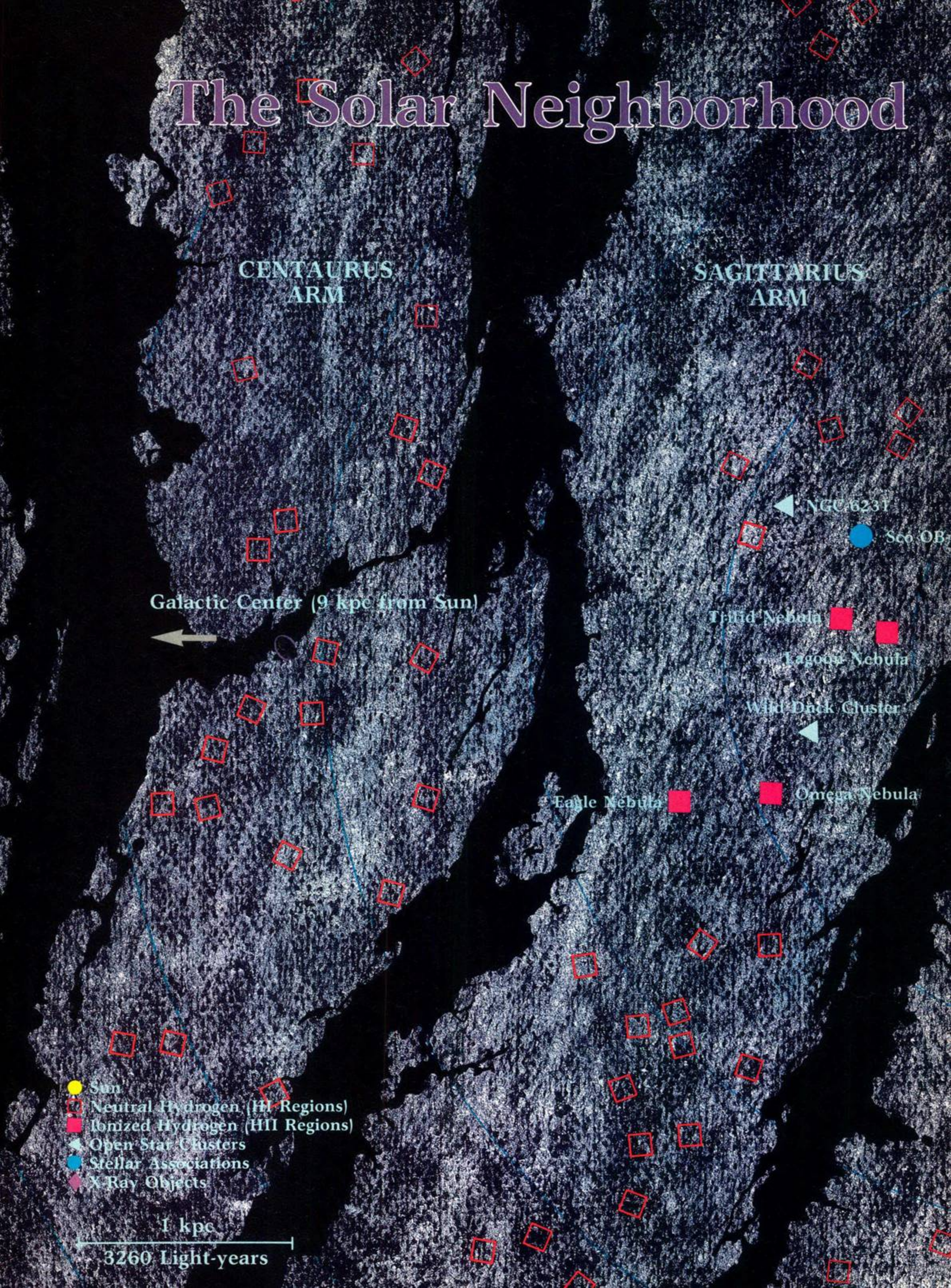
We now have evidence for an even larger corona — one extending 60,000 parsecs from the center of our Galaxy. Studies made by Hale Observatory astronomers of 12 globular star clusters at distances between 20,000 and 60,000 parsecs from the galactic center show radial velocities far greater than we would expect if these clusters were isolated in intergalactic space. If they were isolated — not held back by the gravity of a massive corona — their velocities would carry them out of the Galaxy, never to return. Since they are gravitationally bound to the Galaxy, their high speeds imply a minimum galactic mass of 600 billion solar masses.

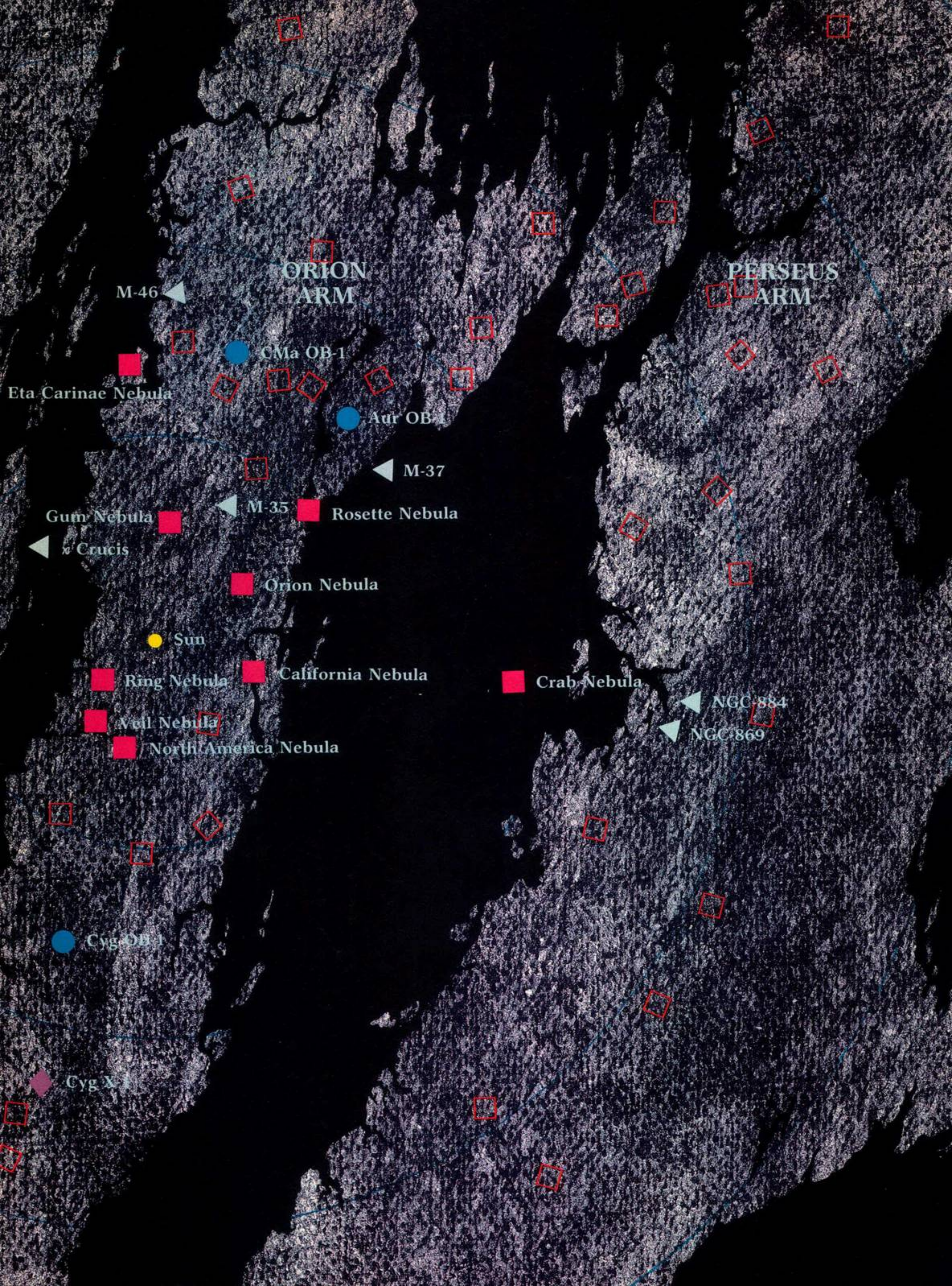
Further evidence obtained from outlying dwarf galaxies extends our estimate of our Galaxy's radius to about 100,000 parsecs — and an estimated minimum total mass of one trillion solar masses. Our familiar Galaxy of 1973 has become the truly Big Galaxy of 1983! The concept of the enlarged Galaxy seems to have been accepted — rather promptly — by astronomers working on research of all sorts relating to our Galaxy.

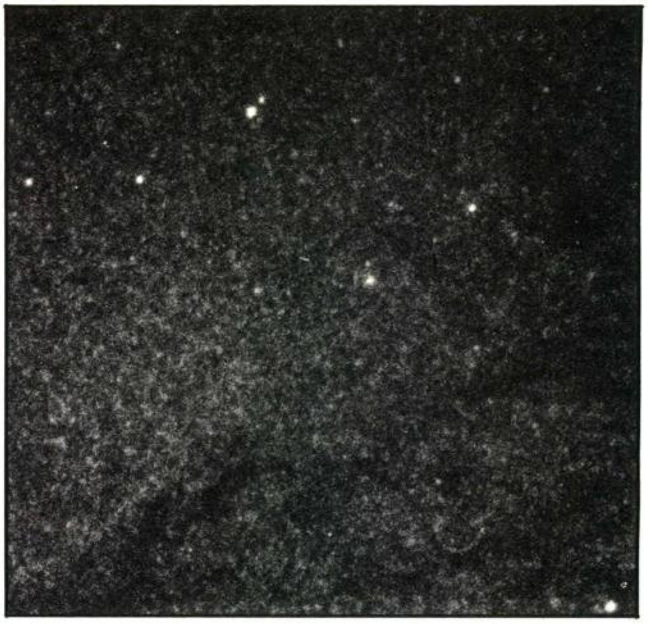
Ten years ago, after devoting years to working on it, I became rather discouraged about prospects for the future study of spiral structure in our Galaxy. We seemed to have exhausted the best techniques for tracing spiral arms. In the optical part of the spectrum, young hot O and B stars and HII regions were the only remaining major tracers of spiral features, especially after we discovered that the longest-period Cepheids didn't just occur in arms, but showed up elsewhere. Distance determinations *still* have a basic uncertainty of 10 percent for O and B stars, so the positions of such stars 8,000 parsecs from the Sun are uncertain by ± 800 parsecs — large enough to give at best a fuzzy picture of spiral structure for the more remote parts of our Galaxy.

In the radio realm the picture was not favorable either. The observed 21-cm hydrogen line profiles were beset

The Solar Neighborhood


CENTAURUS ARM
SAGITTARIUS ARM
NGC 6231
Sco OB
Galactic Center (9 kpc from Sun)
Trifid Nebula
Lagoon Nebula
Wild Duck Cluster
Eagle Nebula
Omega Nebula
● Sun
☐ Neutral Hydrogen (HI Regions)
■ Ionized Hydrogen (HII Regions)
◀ Open Star Clusters
● Stellar Associations
◆ X-Ray Objects
1 kpc
3260 Light-years


ORION ARM
PERSEUS ARM
M-46
CMa OB-1
Eta Carinae Nebula
Aur OB-1
M-37
M-35
Gum Nebula
Rosette Nebula
κ Crucis
Orion Nebula
Sun
Ring Nebula
California Nebula
Crab Nebula
NGC 884
Veil Nebula
NGC 869
North America Nebula
Cyg OB-1
Cyg X-1



Left: The edge-on spiral galaxy NGC-4565 in Coma Berenices provides a good example of what the Milky Way might look like viewed edge-on. Kitt Peak 2.1-meter photo. Right: The central bulge of another similar galaxy, M-31, resolved into stars. Lick Observatory 3-meter photo.

with problems, which led to major difficulties in interpretation.

I had worked on the spiral structure of our Galaxy, as best I could, from the time astronomers William Morgan, Donald Osterbrock, and Stuart Sharpless obtained the cheerful outlines of the principal spiral arms of our Galaxy. In part at the suggestion of Priscilla Bok, I decided in 1973 to switch from the frustrating study of galactic spiral structure to star formation, a shift that I did not regret. However, the last two to three years have brought new developments, based on neutral hydrogen (HI) and especially carbon monoxide (CO) surveys, that are opening up the spiral study of our Galaxy afresh.

At first, the CO results did not look encouraging. It was difficult to disentangle spiral features from local effects produced by what we now call giant molecular clouds, or GMCs. When evidence began to accumulate in favor of the current Bigger and Better Galaxy, it was only natural to pay renewed attention to the study of HI and CO in the outer realms of our Galaxy. In 1973, one survey gave evidence for ordered arrangements of HI in the outer parts of our Galaxy, which astronomers attributed to spiral features. There was promise again! These old data have been re-analyzed with the new rotation curves for our Galaxy, and we can now detect spiral structure out to 18 kiloparsecs from the galactic center. More recently, new CO data have added to the total picture. The largest body of data is that obtained in Australia. This careful study combined southern observations with the northern CO data, and best represents the Galaxy as a *four-armed* spiral; the traditional two-armed spiral simply will not do. The strength of the new model lies, first, in the fact that the velocities agree reasonably well with the observations. Second, the observed holes in the CO distribution diagrams occur where no (two-armed) spiral features are expected. Third, the model has apparent unity and continuity of results for the northern and southern Milky Way. And fourth, with the gradual removal of undersampling, a spiral pattern apparently does emerge. But let me warn you, with results so "hot off the griddle," we must be very careful.

Increasing numbers of optical, infrared, and radio astronomers are turning to the study of the interstellar medium of our Galaxy. The availability of new and improved techniques of observation, charge-coupled cameras, and vastly improved spectrographs on our large optical reflectors, as well as the closing gap between far-infrared and radio astronomy, have opened entirely new vistas for research. With relative ease we can now study the goings-on deep inside the densest dark nebulae in Orion, Ophiuchus, Taurus, the Gum Nebula, and the Southern Coalsack. I consider two areas to be most promising frontier fields: the study of giant molecular clouds and the discovery of bipolar ejection from what seem to be protostars inside dark nebulae.

Most of the star formation in our Galaxy occurs inside huge nebulae composed mostly of interstellar molecules, of which the hydrogen molecule (H_2) is most abundant, and in which the carbon monoxide molecule (CO) is most readily detected. Interstellar dust abounds in these giant molecular clouds; their temperatures are low, about 20° Kelvin — 20° above absolute zero.

In the deep, dark interiors of these clouds, astronomers believe they have detected protostars. The detection of the protostars came from using new techniques at far infrared wavelengths, where the obscuring clouds are transparent enough to reveal what goes on inside them. Twenty protostars exist in the great dark cloud of the constellation Ophiuchus, all part of a gravitationally bound cluster.

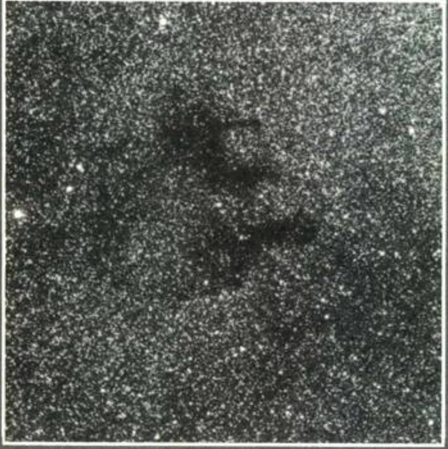
Star formation also operates at the outer edges of the Giant Molecular Clouds. A bright gaseous nebula like the Lagoon Nebula (M-8) has inside it a cluster of young, massive stars — all very hot O and B stars. The cluster stars send out intense ultraviolet radiation, which heats the cloud's cold gas. A shock wave pushes into the cloud, causing some of the dust and gas to collapse. These contracting "snowballs" of gas and dust become protostars belonging to a new young star cluster. After about 10 million years, the first nebula and star cluster evolve into an older, placid affair and inside them, a vigorous young nebula and cluster, which were once part of the molecular cloud, now produce a shock wave that creates yet another young nebula and associated cluster.

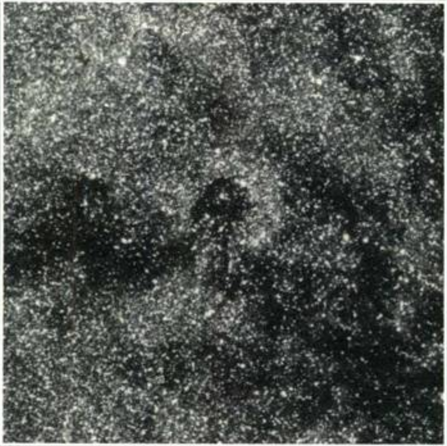
Since their discovery in 1975, astronomers have found that many GMCs exist in our Galaxy. They are studied extensively by astrophysicists interested in the interstellar gas in the Milky Way. The astronomical community as a whole, however, has been slow in admitting them to the inner sanctum of key components of our Galaxy.

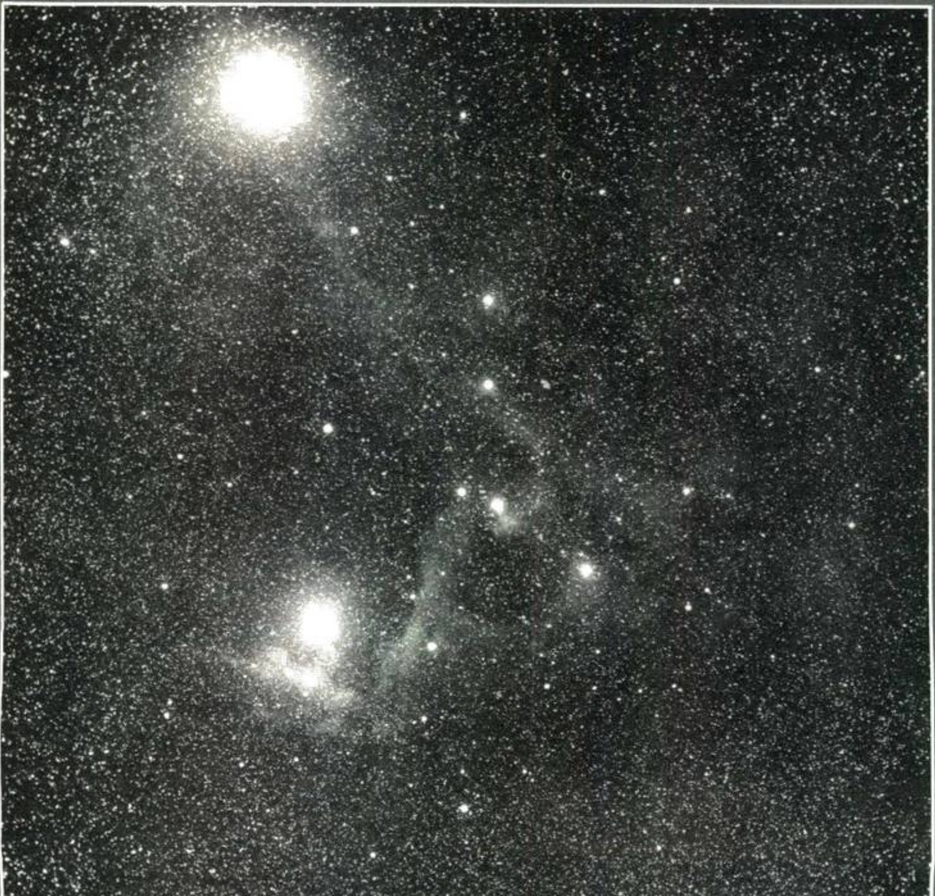
The total number of GMCs in the Milky Way falls somewhere between 660 and 4,000. They are present wherever molecular hydrogen prevails. The largest and most massive clouds have diameters as great as 100 parsecs and masses that may run to 1 million to 10 million solar masses. They are not long-lived — their life span from maturity to ultimate disintegration falls between 100 million to 1 billion years. We really don't know how they formed, but one guess is that they coalesced from smaller clouds during encounters near the central plane of our Galaxy. The relatively high concentration of these giant clouds in the central galactic plane suggests this. About 10 percent of their available gas contributes to the

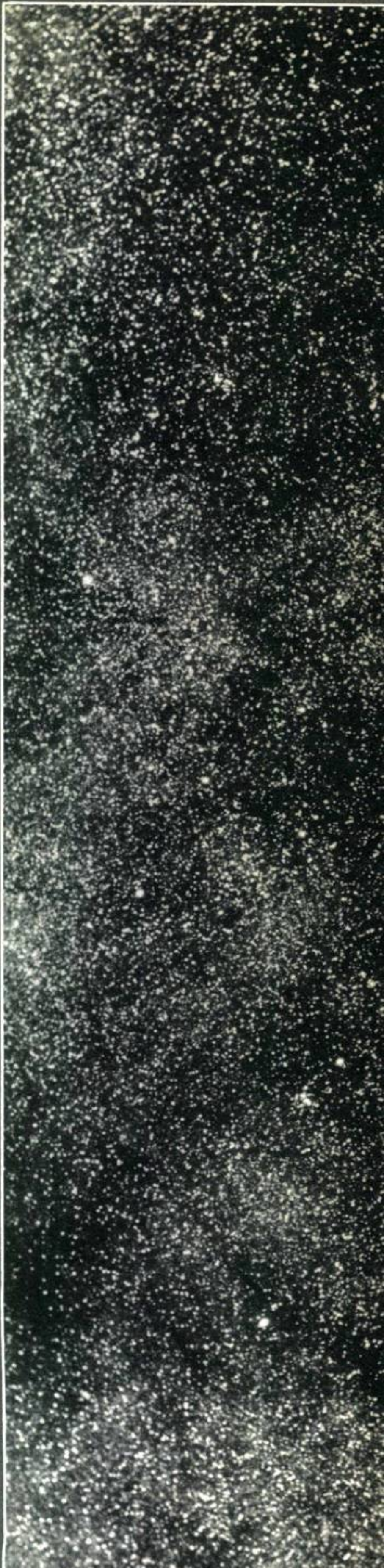
A BARNARD PORTFOLIO

During the early 1900s, pioneering celestial photographer Edward Emerson Barnard systematically created a collection of classic Milky Way photographs as he catalogued dark nebulae throughout the sky. The dark nebulae now bear his name, and although his photographs are nearly 75 years old, they remain some of the finest examples of wide-field pictures of our Galaxy. Right: The Sagittarius Starcloud, M-24, showing two prominent dark nebulae on its northern edge. The Omega Nebula, an emission region, appears at top. Below right: Barnard 87, the so-called Parrot's Head Nebula, in Sagittarius. Bottom: The region of Delta (δ) and Pi (π) Scorpii showing filamentary strands of gaseous nebulae illuminated by the bright stars. Below left: Barnard 142 and 143, which combine to make a giant "E" in the sky, near Altair in the constellation Aquila.

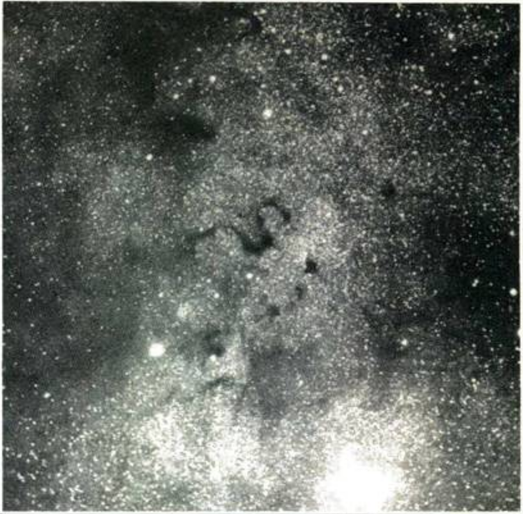




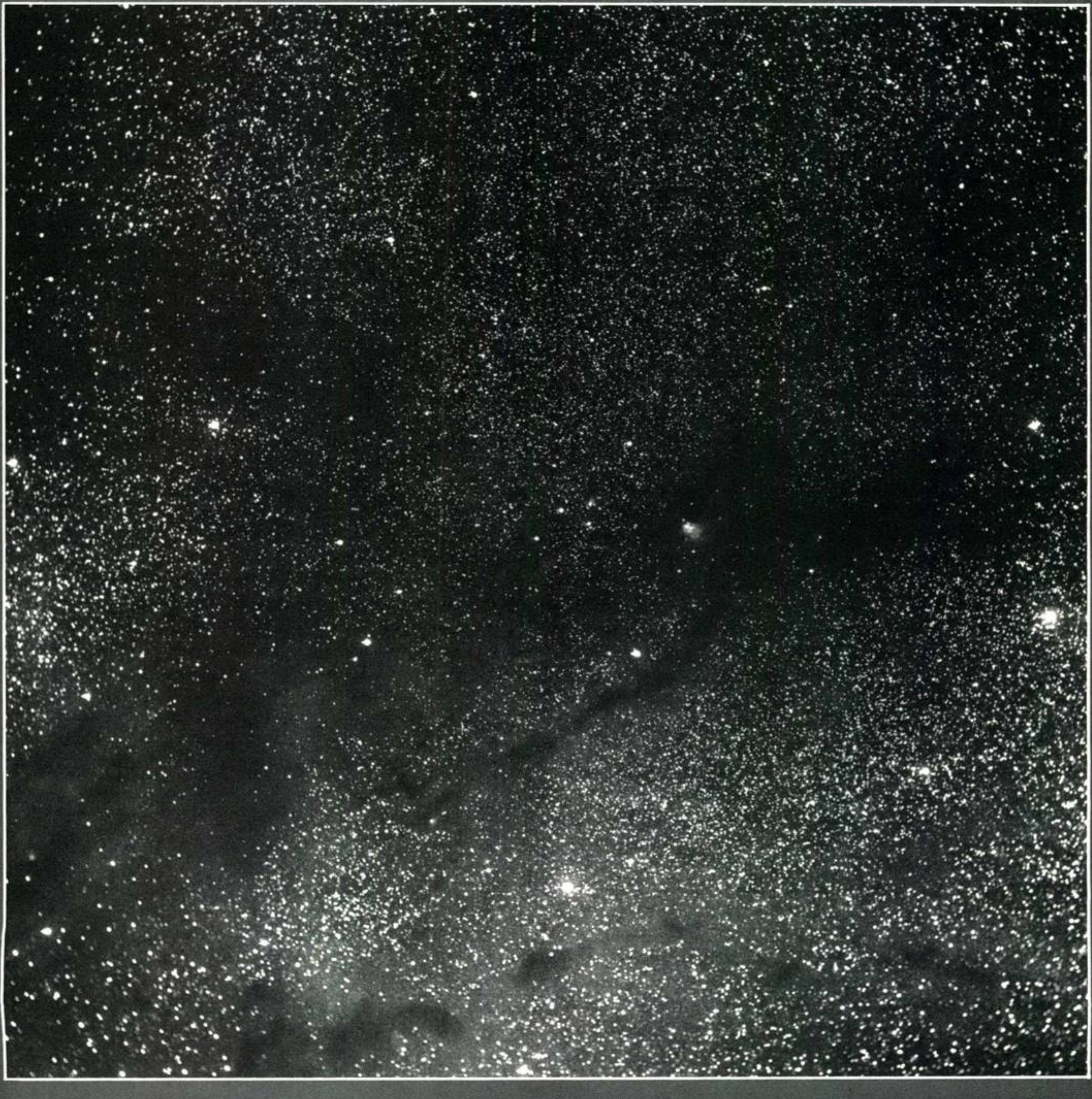


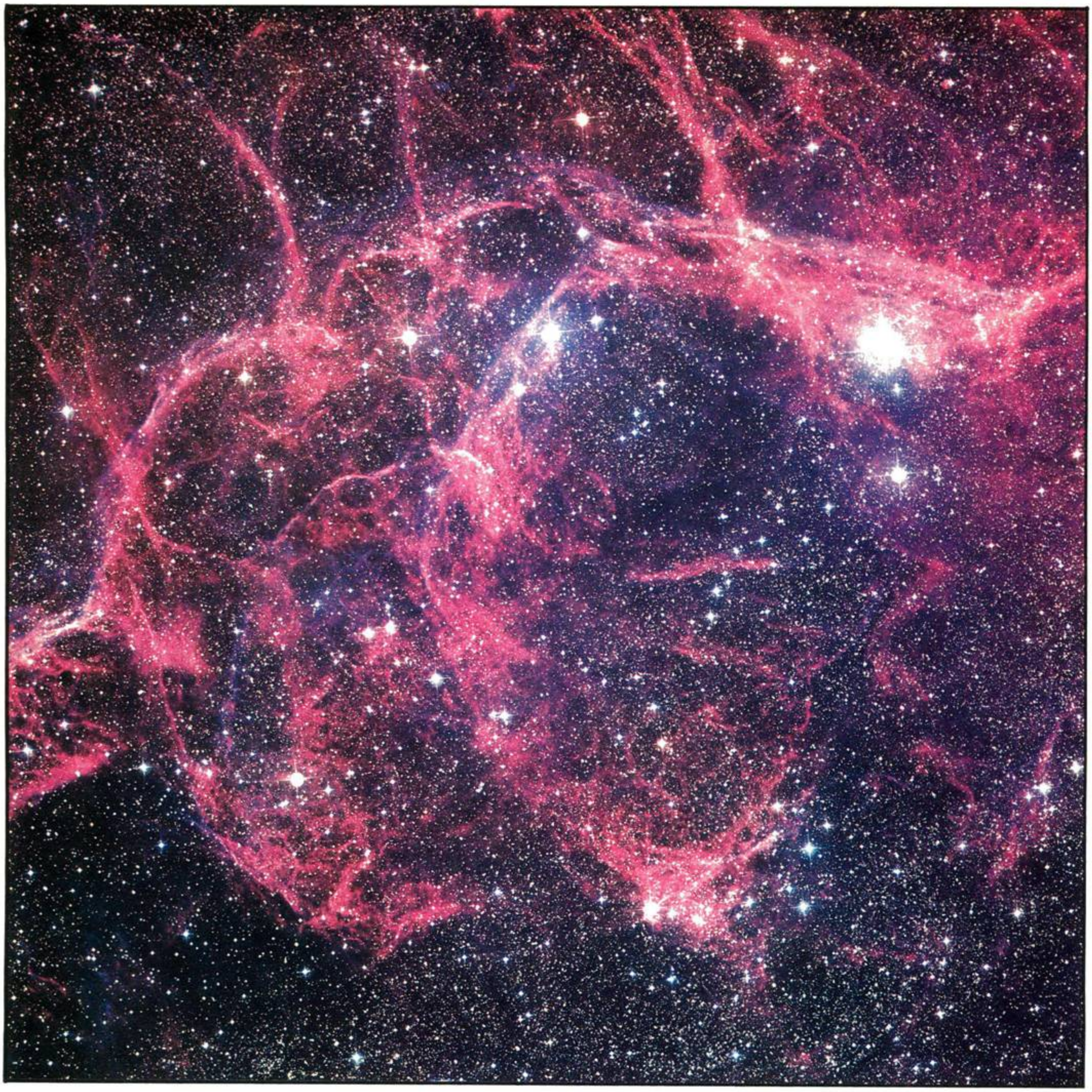


A BARNARD PORTFOLIO



Below: A region of nebulosity in Taurus backlights long tubes of dark nebulae running alongside each other for light-years at a stretch. Note how the star density radically changes from point to point across the face of this photograph. Right: The area surrounding Theta (θ) Ophiuchi includes Barnard 72, the famous S-shaped Snake Nebula. Photographs in this section are from E.E. Barnard's *Photographic Atlas of Selected Regions of the Milky Way*, published in 1923.





One of our Galaxy's more exotic objects, the Gum Nebula in Vela, is an enormous supernova remnant made of ionized hydrogen gas. Blown into space 11,000 years ago, this gas will disperse into the interstellar medium, and be recycled at some distant time. Copyright © 1979 Anglo-Australian Telescope Board.

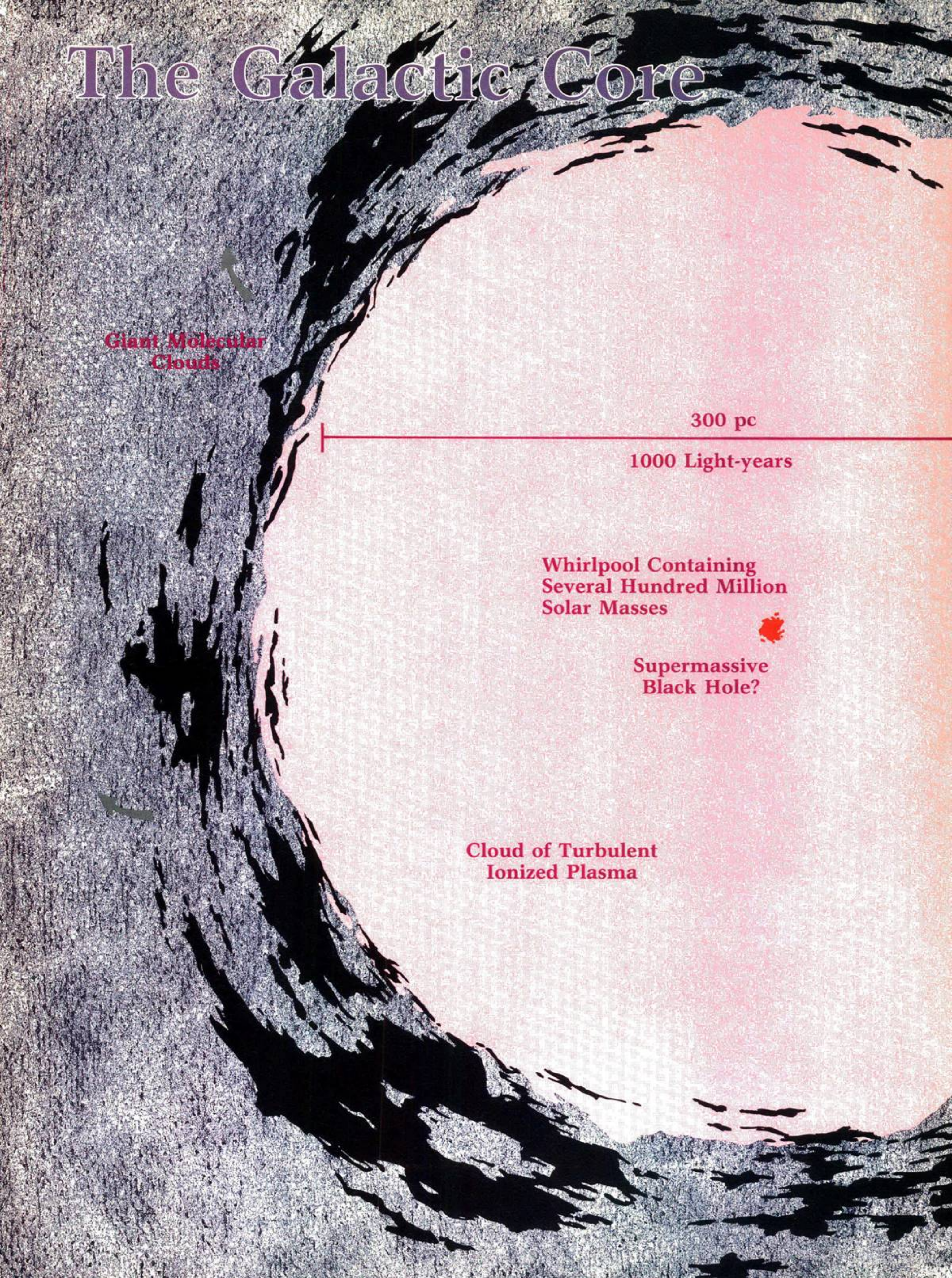
formation of young stars; the remainder ultimately disperses to become part of the general interstellar medium.

Giant molecular clouds seem to have a preference for spiral arms, which may not be accidental. One theory for the formation of spiral features calls for the passage of a spiral density wave — caused by gravitational effects — through the interstellar medium. What would be more natural for the gravitational wave than to push small cloudlets together into large ones? The molecular clouds thus formed would soon possess enough self-gravitation to survive, rather than dissipate, and create favorable conditions for star formation in their interiors.

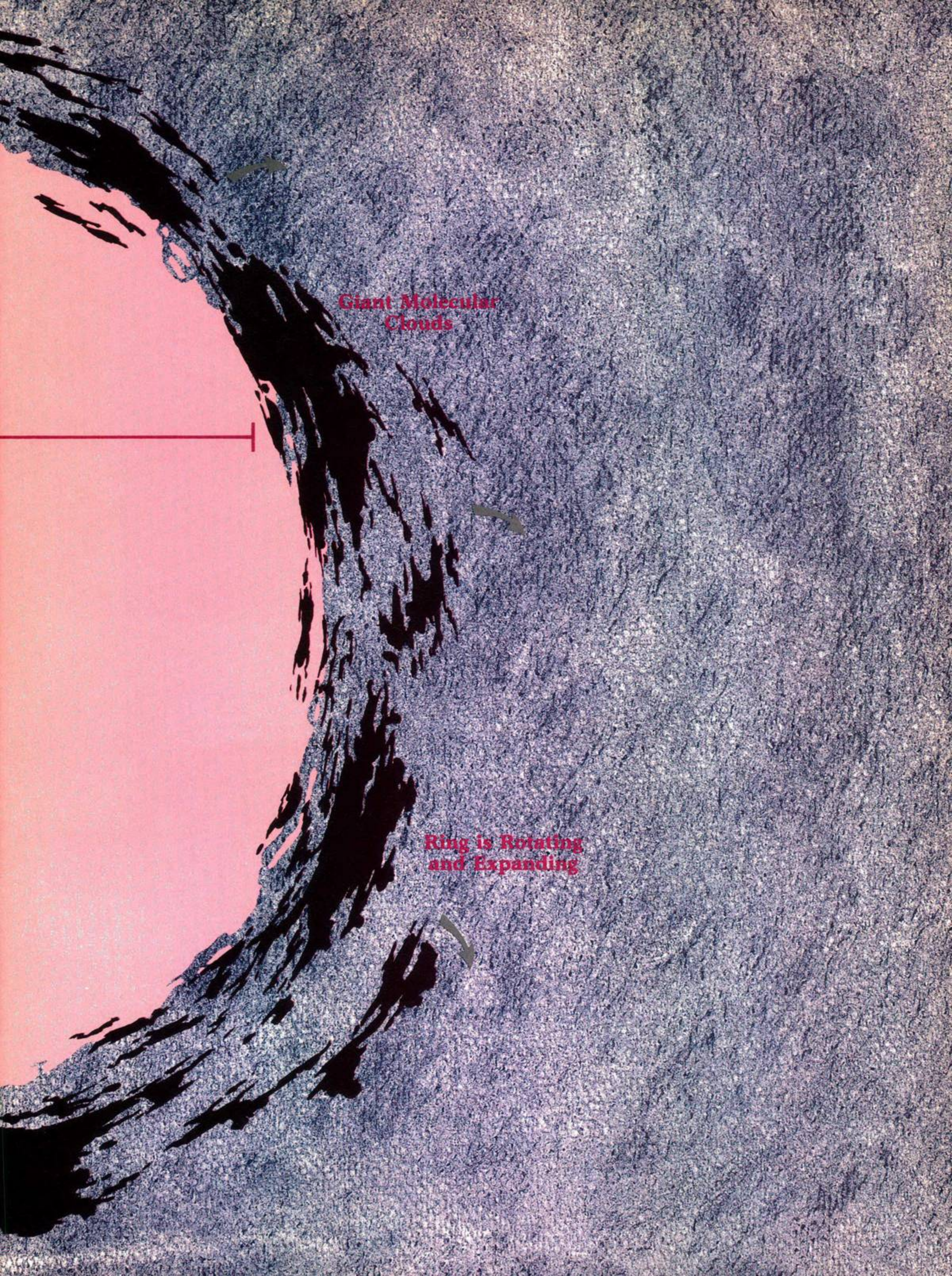
Observational studies in regions of star formation yield many suprises, one of which is that associated with small gas and dust clouds we often find protostars emitting powerful streams of gas into nearby space. It appears that such emanations are especially found in protostars embedded in small dense clouds of gas and dust — the so-called globules. Globules often appear as near-circular dark spots three to five arc minutes in diameter projected against the starry background. The protostar inside them, detectable only by telescopes operating in the far infrared, seems to be rotating and shooting out streams of hot gas from opposite poles at speeds between 100 to 300 kilometers per second. How and why they manage to do this is not at all clear, but there can be no doubt that powerful little jets are shot out by protostars.

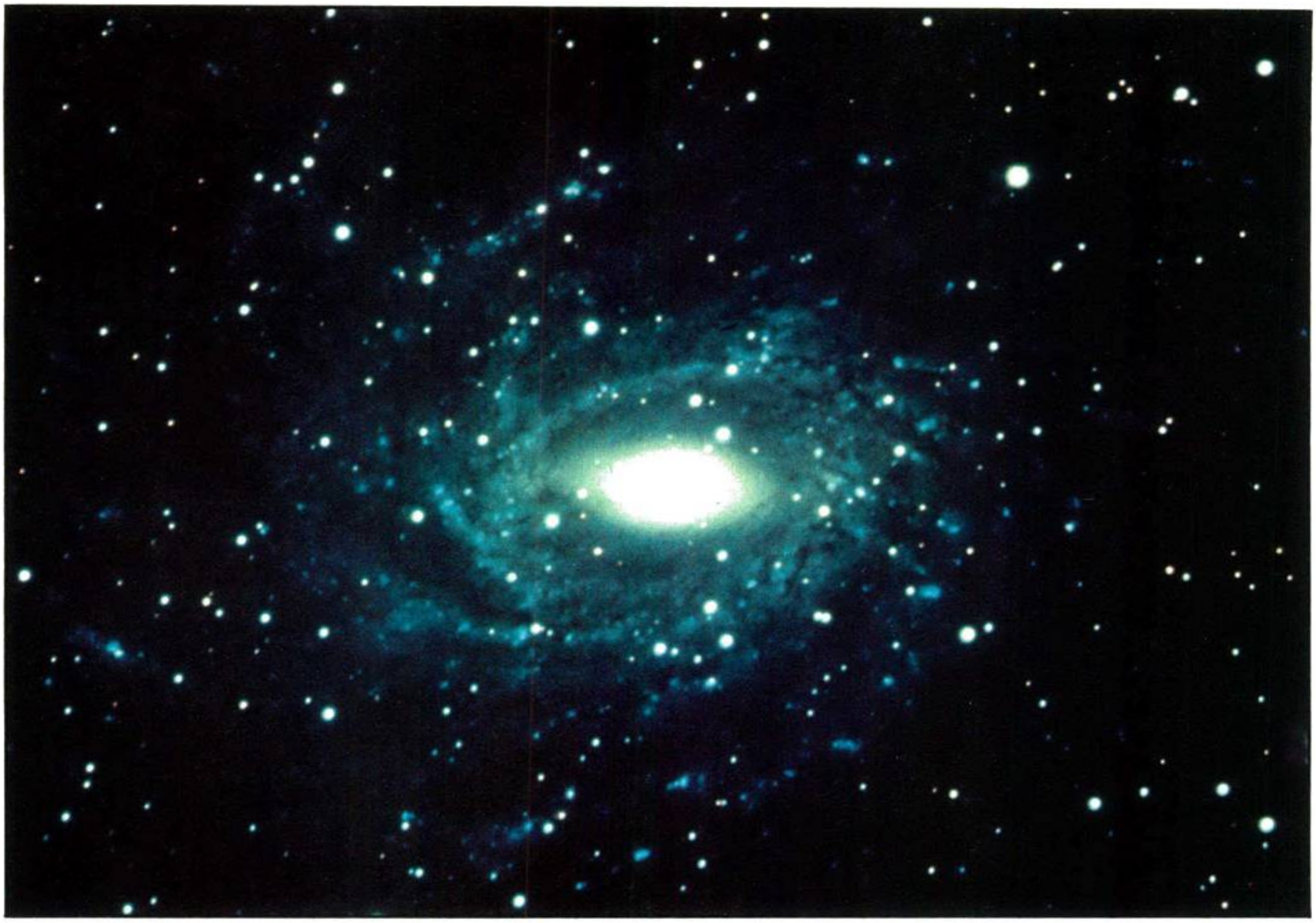
Bipolar ejection is generally found close to a buried infrared source, mostly within a light-year of the source.

The Galactic Core



Giant Molecular Clouds
300 pc
1000 Light-years
Whirlpool Containing Several Hundred Million Solar Masses
Supermassive Black Hole?
Cloud of Turbulent Ionized Plasma


Giant Molecular Clouds
Ring is Rotating and Expanding



What of the past and future of the Milky Way? What will happen to us as we rotate about our Galaxy's hub? We don't know, but studying other nearby galaxies is certain to strengthen our grasp of how and why galaxies behave the way they do. NGC-6744 photo courtesy Rice University.

The ejection is redshifted on one end, blueshifted on the other. Although the region of high-velocity molecular flows is limited in size, it often includes one or more Herbig-Haro objects — small concentrations of gas and dust associated with the final stages in the evolution of a protostar. The calculated energies associated with bipolar outflows are large, and one wonders how the young infrared objects get their pep! These flows are not side effects of gentle interstellar winds. The total estimated mass for the ejected gas ranges all the way from less than one solar mass to 100 solar masses. There is direct proper motion evidence to support that these are real outflows.

A fine example of bipolar ejection is the southern globule ESO 210-6A, located at right ascension 8h 24m, declination −50° 52′ (1950 coordinates), near the edge of the Gum Nebula in the constellation Vela. In 1977 astronomers discovered two Herbig-Haro objects nearby, HH 46 and HH 47, and studied their spectra. I had long been interested in this globule and took a long exposure of it and its surroundings with the Cerro Tololo 4-meter reflector on Valentine's Night in 1978. The photograph shows the two HH objects beautifully together with the umbilical cord that unites them.

What does it all mean? Presumably the HH objects are accelerated and shock-heated by the ejection from the parent protostar. But what goes on inside the protostar? I have no clue, and neither — to the best of my knowledge — have my colleagues. I had always pictured the collapse of a cloudlet into a protostar as a peaceful phenomenon, mostly gravitational in character. It is now obvious that other, more violent, forces are at work as well.

In closing, I want to remind you that Milky Way research has been active in many other areas. I have not covered everything here. The central bulge, the real core of our Galaxy, which has either a very massive grouping of dying stars or a massive black hole at its center, is studied with fervor by radio astronomers and by infrared astronomers; it is also a fine subject for investigation by high-energy astrophysicists. Keep an eye on our center!

Another area that deserves mention is the study of globular star clusters in our Galaxy. The globular clusters are the most conspicuous old component of our Galaxy. Their ages since formation — which we can obtain from studies with spectrographs attached to large telescopes — range from 1 billion to about 15 billion years. For comparison, you will recall that our Sun and Earth formed an estimated 5 billion years ago. The oldest globular clusters must have been created close to the start of the Big Bang; they can help us tremendously in deciding what conditions existed at the start of our universe.

We can deduce from all of this that the study of our Home Galaxy, the Milky Way, is alive and well. New discoveries and unexpected new phenomena make it a constant pleasure to be involved in Milky Way research.

Bart J. Bok, Professor Emeritus at the University of Arizona and world-renowned expert on the Milky Way Galaxy, died at his home in Tucson several weeks after completing this, his last article.

Low Prices, Fast Service, Free Catalog, Giant Selection...And Your Call Is On Us!

Call Toll Free! **800-447-1001** IN CALIF. 800-443-1001

CELESTRON · Meade · BAUSCH & LOMB · Edmund Scientific · AccuTrack™ · Tele Vue · BUSHNELL

- ★ **Personal checks, Master Card, Visa gladly accepted.**
- ★ **FREE shipping when you pay by check!**
- ★ **FAST shipment—most orders shipped within 24 hours!**
- ★ **Call TOLL FREE for any reason (not limited to 'orders only')!**
- ★ **Free expert advice, even if you are buying elsewhere.**
- ★ **Safe delivery, fully insured, absolutely guaranteed.**
- ★ **Unconditional money-back satisfaction guarantee!**

Why Buy From Orion?

Orion is your fast, friendly, professional telescope source. Our experienced staff can answer your questions, make honest and objective recommendations, and speed your order to you pronto.

Our huge FREE catalog is yours for the asking. You'll find hundreds of Celestron, Meade, and other products, plus many of our own unique accessories you'll really like.

Telescopes

We know telescopes, and can give you unbiased advice on any brand or type. Just a few models shown here.

Meade 4" Spotter

Celestron C-80 80mm Refractor

Celestron Super C-8

Meade 826 Reflector

Edmund Astroscan 2001

Celestron Comet Catcher

Meade 2080/2120

Celestron C-6 6" Reflector

B&L Criterion 4000

Accessories

Hundreds of useful products from TeleVue, Celestron, Meade, and our own Orion brand. See catalog for full listing!

Illuminated Reticle Eyepiece

Tele-Vue Eyepieces

Orion Observer's Chair

Giant Binoculars

Lightweight Dew Caps

Lectra-Sox

Handy Eyepiece Case

Giant Finder Scopes

Orion Eyepieces

Electronics

AccuTrack electronic control systems, the largest selection of quality equipment for visual and photographic use.

Declination Motor Drive

FasTrack Dual-Axis Controller

AC/DC Drive Speed Control (3117)

AutoGuide Star Tracker

AccuTrack MiniDrive

Dew Zapper II Dew Eliminator

Digital Quartz Controller

ORION'S UNBEATABLE GUARANTEE

If you are not completely satisfied with your mail-order purchase from Orion, for any reason, just return it in new condition within thirty days after delivery for an immediate refund. You be the judge!

MasterCard · VISA

Our 8th Year Of Service

ORION TELESCOPES

P.O. Box 1158-A
Santa Cruz, CA 95061
(408) 476-8715

In Search of the Magellanic Clouds and Other Southern Delights

We had trudged more than a mile down the side and halfway across the floor of an ancient volcanic caldera in central Java. It was dark there at 3 a.m. that clear moonless early morning. Blankets wrapped around our shoulders against the 45° F cold, we spotted the Large Magellanic Cloud hanging like a deliberate smudge in the southern blackness.

At last that elusive galactic neighbor was ours!

The fact that the Tarantula Nebula was on the upper right side when it should have been to the lower left didn't sink in until later. We were too busy trying to figure out this strange sky where Scorpius was setting upside down in the west, claws first, seeming to dig his way into the edge of the Earth; the Sagittarius teapot steaming no longer but spilling its contents entirely onto the horizon; the Summer Triangle pointing the "wrong way." Not to mention completely foreign sets of stars forming who-knew-which southern constellations.

And we had another mountain still to climb and other things to observe before dawn broke at 4:45 a.m. — the fiery mouth and jet-engine roars of Mt. Bromo, an active volcano, and the site of consistently glorious sunrises as a result of the volcano's activities.

The total solar eclipse provided the reason for our trip to Indonesia, but the lure of the southern skies had given us another strong incentive to journey to the other side of the world 8° below the equator. Now it seemed as if we'd finally found the LMC.

We had started searching for it in January 1982 on vacation in Mazatlan, Mexico, just south of the Tropic of Cancer, some 23° north of the equator. As most amateur astronomers eventually must, we yearned to see celestial delights hidden from us by our literally limited horizons. We figured we might have a chance of seeing it in Mexico — even though it could be very close to the horizon, making a shallow arc in the far southern sky. So on two successive evenings, when the tropical nighttime clouds cleared enough, we walked around with a pair of binoculars looking for some sort of view protected from all the street lights. The LMC would be about 10° south and somewhat east of Achernar at the end of Eridanus, the long river falling from the knee of Orion. But though we searched for several intense hours, squinting and averting our vision, we did not find the LMC.

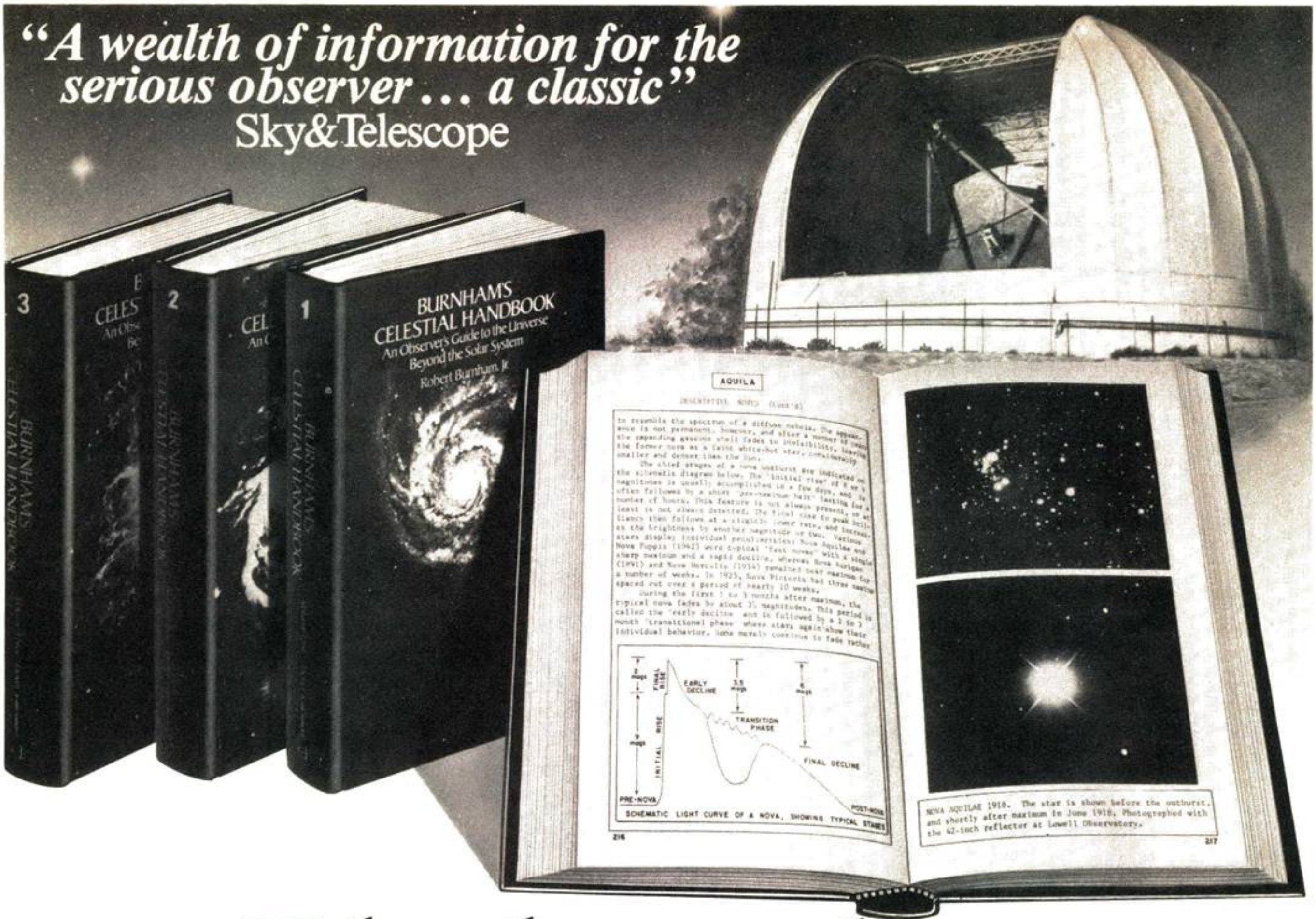
Ronald Royer

In compensation, perhaps, the sight of Eridanus was awesome. That starry river flows down a full 60° southward on its long journey to where first-magnitude Achernar shines brightly. Even as we pulled out on the evening train a few days later, we were still gaping at the longest constellation in Earth's sky (130°!). No LMC in Mexico, we concluded, but we'd found a different secret: Spreading one's astronomical horizons is a thoroughly satisfying activity, though it has frustrations imposed by time and weather and the phase of the Moon. Our appetite for discovering other southern sights had increased.

Arriving in Java a year and a half later, we had little time for seeking new night skies as we prepared for the solar eclipse, though we did notice with a quick thrill prominent Alpha and Beta Centauri and Crux in the south and the Big Dipper absurdly low on the northern horizon, pointers uselessly gesturing off the map.

But now on Mt. Bromo, the eclipse successfully seen, we could begin. The binocular view of what we thought was the LMC was a bit disappointing, being featureless in detail. We discovered why the next day: We had actually found the Small Magellanic Cloud (SMC). Had we not celebrated but looked further, we might have spotted our real quarry. Instead of the Tarantula Nebula, we had seen 47 Tucanae, the second largest globular cluster after Omega Centauri (which we can view regularly low on the horizon from our home in San Diego). Indeed, our eyes had clearly recorded a soft, smooth though breathtakingly large glow with a surprising globular cluster in front of it. That is how SMC and 47 Tucanae are described, and that is how, in fact, they appear. A pleasant bit of perceptual knowing. But the LMC had slipped through our net.

On to Bali, where our search for southern astronomical goodies encountered another problem common to all astronomers . . . the Moon. We love her and view her often, but we also like to look at other things. If we were to get the LMC easily, it would have to be early morning before Full Moon. We rented bikes our first day in Bali and rode 15 miles or so, looking for and finding a good viewing spot, prepared a detailed written viewing program with items arranged in order of importance, and went to bed, alarms set for 3:00 a.m. Too excited,


"A wealth of information for the serious observer ... a classic"
Sky&Telescope
BURNHAM'S CELESTIAL HANDBOOK
An Observer's Guide to the Universe Beyond the Solar System
Robert Burnham, Jr.
AQUILA

Take the 3-volume Burnham's Celestial Handbook for only $3.95 when you join the Astronomy Book Club

a $60.00 value

You simply agree to buy three more books—at handsome discounts—within the next 12 months.

The most complete sky manual ever. Three easy-to-use hardcover volumes (a $60.00 value) guide amateur and professional astronomers to a greater knowledge and enjoyment of the stars. Detailed coverage of 7,000 deep-sky objects that are accessible to observers with telescopes in the 2" to 12" range. Provides names, celestial coordinates, classification and complete physical descriptions of almost every deep-sky object.

Entries are grouped according to constellation with extensive descriptive notes covering historical and mythological associations, unusual movements and appearances, plus explanations of white dwarfs, novae and supernovae, dark and gaseous nebulae and hundreds of other topics. Numerous charts, diagrams and graphs included to help in identification. More than 2,000 pages containing over 600 photographs.

"Totally professional and competent in virtually every respect, *The Celestial Handbook* is for anyone who follows the stars."—*Star and Sky*

Astronomy Book Club is a very special club—a book club operated exclusively for astronomy enthusiasts. It's devoted to making the finest astronomy books available conveniently and inexpensively. Recent offerings include titles by such eminent authorities as Carl Sagan, George Abell, Robert Jastrow, and John Gribbin.

As an **Astronomy Book Club** member, you'll receive books of your choice at savings up to *30% off publishers' prices*, and occasionally even more. In addition, you'll immediately become eligible for our Bonus Book Plan, with savings up to 70% off the publishers' prices.

Discover the phenomena of space—join the **Astronomy Book Club** today.

If reply card has been removed, please write to: **Astronomy Book Club**, Dept. L-BA2, Riverside, N.J. 08075 to obtain membership information and an application.

4 Good Reasons to Join

1. The Finest Books. Of the hundreds and hundreds of books submitted to us each year, only the very finest are selected and offered. Moreover, our books are always of equal quality to publishers' editions, *never* economy editions.

2. Big Savings. In addition to getting BURNHAM'S CELESTIAL HANDBOOK for only $3.95 when you join, you keep saving substantially—up to 30% and occasionally even more. (For example, your total savings as a trial member—including this introductory offer—can easily be over 50%. That's like getting every other book free!)

3. Bonus Books. Also, you will immediately become eligible to participate in our Bonus Book Plan, with savings up to 70% off the publishers' prices.

4. Convenient Service. At 3-4 week intervals (16 times per year) you will receive the Book Club News, describing the Main Selection and Alternate Selections, together with a dated reply card. If you want the Main Selection, do nothing and it will be sent to you automatically. If you prefer another selection, or no book at all, simply indicate your choice on the card, and return it by the date specified. You will have at least 10 days to decide. If, because of late mail delivery of the **News,** you should receive a book you do not want, we guarantee return postage.

we awoke at 1:00 and were up and down for hours with tropical clouds frustrating our every effort. Same the next night, and then Full Moon took over, which naturally rose after the partial lunar eclipse was completed (on June 25).

Weather again intervened in early evening as the Moon rose later and later, until two days before we were to leave. Then we got a good view of the major southern constellations — Ara, Triangulum Australis, Centaurus, Crux, Musca, Carina and Vela. Together they constitute the most brilliant swath of stars available to earthbound eyes. It's not just the well-known first-magnitude stars packed into such a small area — what stuns the eye is the amazing number of second and third-magnitude stars. Centaurus alone has 18 stars brighter than 4.0 magnitude, as does Carina, while Vela has 17. Even tiny Crux has 8. We do not exaggerate when we say it's the finest naked-eye stellar vista in the heavens.

But cloudy curtains slowly closed overhead before we could do any binocular and telescopic observing.

We had only one more night, and we know it's as corny as Kansas, or maybe it was the work of some of the multiplicity of fearsome and playful Balinese spirits we'd read so much about, but sure enough, on our very last evening in beautiful Bali, the inevitable clouds held off and stayed away almost until the Moon rose. We were given time to enjoy the new view of the stars, time to trace out the constellations and spot in binoculars some of the many deep sky objects on our various carefully-written-out viewing programs. Time even to view them through a small but effective 4¼-inch Newtonian. With a 12mm ocular, it gives 32x.

We started with doubles, going straight for Alpha Centauri first, our nearest stellar neighbor. What a sparkling bright pair at 0 and 1.2 magnitude, 8.7″ separation. We couldn't split the 4.4″ separation of Acrux, but wide Beta Crucis (44″ separation) provided a gorgeous 1.5 and 11 magnitude contrast.

We then followed out a series of stunning open clusters, first spotting the Kappa Crucis cluster (NGC-4755), bright, triangular — easy to see why it's called the "Jewel Box." Then a dim though nice cluster, probably better in larger scopes, NGC-3736 in Centaurus west of Crux, near the top of a long lovely curving "S" of fifth-magnitude stars. Still moving west into Carina we came to NGC-3532, very large, scores of dim stars, quite extended, spectacular. Further west was the unusually bright compact cluster NGC-3293. Then dropping south we found the even more extended IC 2602 clustering around Theta Carinae.

Then back to Crux for a view of the blankness of the Coal Sack. We couldn't see a thing in the telescope — perfect! Finally to Omega Centauri, high up almost overhead, a fine sight at 32x, but we upped it to 42x and lingered over the finest globular cluster in our planet's entire sky.

But the best was last and, appropriately for us amateurs, was seen naked eye. For by now both Scorpius and Sagittarius were up and we could step back, as it were, and contemplate the Home Galaxy. Forget the disappointment at not seeing the LMC and that too-brief view of the SMC, forget the almost nightly frustrations caused by tropical heat and moisture, forget even the stellar delights and the telescopic sights we had already enjoyed.

For now we could see our own Galaxy intimately and from the equatorial perspective it seemed to be made for. We watched the spiral begin to fatten at Scutum and then grow through Sagittarius and across Scorpius, but not stop there, in the middle, as it does from northern latitudes. No, it flowed on, under Centaurus and through Ara and Norma, into Musca, eddied around the Coal Sack in Crux and the Great Rift in Vela. Here indeed is a monstrously large view of an edge-on spiral galaxy . . . the best we humans will ever have. What a gift we had received. And simply because we had traveled to the other side of the rotating sphere on which we dwell. The sense of Earth's position with respect to our Galaxy adds a final dimension to the celestial movements astronomers can observe and experience.

As for the Magellanic Clouds, maybe we'll go farther into Mexico and catch them there. Or we may just go to Peru early in 1986, visit the great temple at Macchu Picchu, nearly 13° below the equator, and catch Halley's Comet as well. If we don't find the LMC then, we'll simply keep having a good excuse to go traveling.

— *Stephanie and John Mood*
San Diego, CA

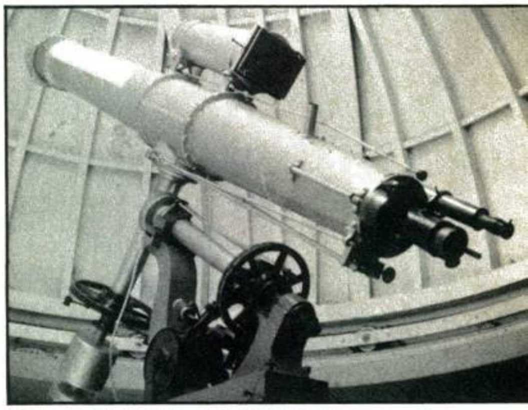
100 Years at Chabot Observatory

When traveling, I usually phone a planetarium I know little about to arrange to see the sights and find out what they do. Nine years ago, during my first visit to the San Francisco Bay area, I discovered something that has made a big difference in my life.

Rotary Chabot Planetarium in Oakland was listed as having an affiliation with the school district and the most common planetarium projector, a Spitz A-3-P. Planetarium director Kingsley Wightman graciously showed me around. What began as a standard-duty school planetarium visit quickly mushroomed into a perfectly boggling experience. Chabot Observatory (pronounced sha-BO) has practically every kind of astronomy facility an amateur could want. Most of them are on a grand scale, but the breadth and quality of the astronomy that people pursue there is even more impressive.

Chabot Science Center huddles in the Oakland Hills. Through a hole in the tall eucalyptus trees you can see southern Oakland; not far enough beyond glares the stadium where the A's play. Half a dozen undistinguished white buildings rise from the blacktop parking area. The planetarium, a Rotary Club gift, offers school and public shows in a tall structure halfway down the hillside. But the truly striking building is the elegant old observatory, a not-too-miniature version of Allegheny, Lick, or Yerkes. In turn-of-the-century style, imposing domes cap the ends of the building; a classic transit telescope rests between. The main dome gleams impressively — but I've learned to marvel at what goes on in the plainer buildings, too.

Any school district is glad to have its planetarium augmented by a telescope or two for evening viewing. If the telescope is a century-old Alvan Clark, terrific, and if it has an 8-inch lens, it's the centerpiece and focus of pride. Chabot's 1883 Clark is indeed a fine 8-inch, used more than 100 nights each year, both by the pupils and by members of the Eastbay Astronomical Society. It bears unique testimony of *heavy use — the reeding* on the focus knob is worn smooth!

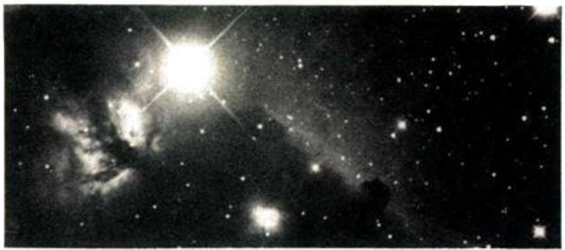

Century-old 8-inch Clark refractor.

But at Chabot, the Clark scope is not the highlight, just an appetizer. In a

Meade & Celestron
LUMICON Carries a full line of telescopes & accessories. Fast Delivery, competitive prices. Both Catalogues $3.

HIGH PERFORMANCE TELESCOPES

ASTROPHOTO OF THE MONTH



Horsehead Nebula IC434 and reflection nebulae IC435 (below Horsehead) and NGC 2024. The Horsehead Nebula is seen best with a LUMICON H-Beta Filter. The reflection nebulae are seen best with a LUMICON DEEP-SKY Filter. 20 min. exp. Photo by Dr. Jack Marling using a LUMICON Newtonian EASY-GUIDER, 8"f/4.5 telescope and 2415 film sensitized in a LUMICON Model 300 HYPER-KIT.

LUMICON® FILTERS STOP LIGHT POLLUTION

The **LUMICON DEEP-SKY Filter**™ improves both visual and photographic contrast on all deep-sky objects, including galaxies. The **LUMICON UHC Filter**™ is for viewing only and yields the highest contrast for planetary and emission nebulae of any filter available today.

Filter Type	UHC	Deep-Sky
For 0.965" eyepieces	—	$49.95
For 1¼" eyepieces	$79.50	$59.50
48mm for 2" eyepieces	$119.50	$99.50
For 2" eyepieces & photography		$99.50
Set, 1¼" UHC & Deep-Sky Filters		$119.50
Selected premium filters		add $20

H-Beta Filter, 1¼" . . . . $69 48mm $119

H-ALPHA PASS FILTER

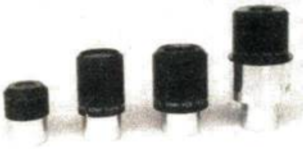
Yields spectacular contrast gains in B&W photography with telephoto lenses. Yields pinpoint star images. Superb with hypered 2415. For color, use the Minus Violet (MV) Filter.

Specify Lens Size	H-Alpha	(MV)
46, 48, 49mm	$29.95	$25.00
52, 55, 58, 62mm	$39.95	$29.95
67, 72, 77mm	$46.95	$39.95
82mm	$49.95	

Hypered 2415 film, 36 exp . . . $9.95 . . . 3/$27

TELE VUE™ EYEPIECES USE THE BEST!!

Note: Prices increase $10-$20 on 1/1/84



Plossl, Wide-Field, Nagler Eyepieces

Tele Vue Plossl eyepieces have a sharp 50° apparent field-of-view. The Wide-Field eyepieces have a 65° field-of-view and are sharper than Erfle and Konig Eyepieces. The revolutionary Nagler eyepieces are sharp clear to the edge of a giant 82° field-of-view. **The eyepiece is half the telescope — use the best!**

7.4, 10.4, 13, 17, 21, 26mm Plossl $55
2½X **Tele Vue Barlow** Lens $55
32mm Plossl, widest true field in 1¼" . . $70
55mm 2" Plossl, widest possible field . $150
19mm Wide-Field, 1¼" eyepiece $100
24mm Wide-Field, "superb" $115
32mm Wide-Field, 2" eyepiece $185
40mm Wide-Field, "awesome" $240
4.8mm Nagler, 82° field $125
9mm Nagler, 82° field, "the best" $175
13mm Nagler, 82° field, 1¼" or 2" $200

LUMICON®

2111 Research Drive #5A, Livermore, CA 94550
For phone orders please call (415) 447-9570
LUMICON Products catalogue $2.
Foreign orders add $8 ($20 for HYPER-KITS).
California Residents add 6% tax.
Prices subject to change w/o notice.

SUPER-FINDER™

The LUMICON SUPER-FINDER is both a compact Rich-Field Telescope and a magnificent "Super-Finder". It has a fully coated 80mm achromatic lens and 300mm focal length. The Deluxe SUPER-FINDER has a superb 500mm f/6 air-spaced lens.

10X80mm SUPER-FINDER, with 30mm 1¼" eyepiece $149.95
SUPER-FINDER w/o eyepiece $129.50
IMPORTANT: Select 1¼" or 2" straight-through or right-angle viewing. Right-angle version requires a star diagonal.
DELUXE SUPER-FINDER w/o eyepiece (requires 1¼" or 2" star diagonal) $199.50
1¼" star diagonal, 30mm aperture . . $26.95
2" LUMICON mirror-type star diagonal, threaded for 48mm filters . . . . . . add $89.50
Mounting rings, 3-5/8" I.D $16.95/pair
Mounting adapter for C-8, Meade etc . . . $35

NEW! SUPER C-8, FLUORITE C70 by CELESTRON®

Super Precision Byers Worm Gear Drive
• Precision Optics, Hand-Matched and Certified

HIGH PERFORMANCE 8" TELESCOPE SYSTEM (Black Super C-8 Shown) . . . $1250
Includes your choice of a black or orange Celestron **Super C-8** 8" f/10 complete telescope system.
List price value = **$1620.** Includes a high precision 7" diameter Byers worm gear drive system ideal for astrophotography (10 arc second periodic error), high transmission coatings, 8X50mm right-angle finderscope, equatorial wedge, heavy-duty Meade adjustable field tripod, accessory tray, dew shield, no-tool knob set deluxe latitude adjuster, 26mm (77x) multicoated Plossl 1¼" eyepiece, 7mm (286X) orthoscopic eyepiece, padded carrying case, all standard accessories, star map and finder cards for all the messier objects. Shipping added ($30-$40) for charge orders.

OPTIONS BOOST PERFORMANCE

Starbright enhanced silver coatings boost visual transmission 10-15% (C-8 only) . . $98
LUMICON® Premium UHC Filter . . **add $79**
LUMICON® **Cassegrain EASY-GUIDER and** Rich-Field Viewer ($216 value) . . . . **add $198**
LUMICON Rich-Field Viewer, 2" aperture . . . $99
Deluxe Piggyback Mount, adjustable **$39.50**
LUMICON Deluxe Rich-Field Viewer system w/ 32mm Tele Vue Plossl, 1.5° true field**$169**
200mm f/3.5 superb multicoated lens **$99.50**
Electric Declination for C-8 . . . . $75
Dual Axis Drive Corrector for astrophotography with electric declination $248

New Product!
FLUORITE

Celestron C-70 fluorite refractor with equatorial mount $998
Fluorite objective lenses deliver amazingly sharp and high contrast images with essentially zero color distortion. **Refractor Tube Assemblies** include a 26mm Plossl 1¼" eyepiece, 1¼" star diagonal, rack & pinion focuser, dew cap and 6X30mm finderscope. **Refractor Equatorial Mounts** include adjustable wood tripod, setting circles, slow motion controls, azimuth and altitude fine adjustments, accessory tray, counterweight, and mounting rings. Optional electric drive motor is highly recommended.
C70, 70mm f/8 fluorite refractor ($800 list) . **$695**
C80F, 80mm f/8 fluorite refractor ($900 list)**$845**
Mounting rings (specify for C70, C80F) **$45**
Refractor equatorial mount, ($400 list) . . . **$335**
C80, 80mm f/11.4 refractor & mount complete telescope system ($725 list) **$568**
C70 fluorite refractor & equatorial mount, complete telescope system ($1200 list) **$998**
C80F fluorite refractor & equatorial mount complete telescope system ($1300 list) . . . **$1150**
Electric drive motor & quartz drive corrector ($125 list) **$110**
LUMICON EASY-GUIDER for photography . . . . **add $129**

DEEP-SKY ASTROPHOTOGRAPHY

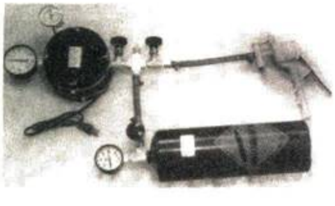
FILM HYPERSENSITIZATION KITS†

LUMICON HYPER-KITS™ yield 3-15X film speed gain in long exposures. They are safe & simple to use. Easy HYPER-KIT includes a chamber with all controls and fittings, thermometer, a refillable cylinder of non-flammable forming gas & hand-operated vacuum pump.

†Patent Pending

MODEL 100 HYPER-KIT for 35mm film, rolled-up. *Takes longer,* but it easy to use. Not recommended for 2415. . . . . **$225.00**

MODEL 300 HYPER-KIT sensitizes any 35mm film in hours. Best for 2415. Achieves highest possible film speeds **$275.00**



MODEL 600 HYPER-KIT [See Photo] Like the Model 300, but also sensitizes 120/220 larger format film and small glass plates **$299.50**

MODEL 1200 HYPER-KIT is for 4X5" plates and film up to 5X7". Has 2 gas cylinders and includes temperature controller . . . **$525.00**

Temperature controller for any HYPER-KIT **$59.50**

Electric Vacuum Pump **$265.00**

GUIDE OFF-AXIS FOR LOVELY ASTROPHOTOS

All **LUMICON EASY-GUIDER**™ off-axis guiders† have both radial and 360° rotational adjustments for 5X eaiser guide-star selection, use 48mm filters, 360° camera rotation, large prisms fo bright guide-starts. *Specify Camera and Telescope type.*

†Patent Pending

NEWTONIAN EASY-GUIDER™

Full aperature. Installs in secs. Specify 2" or 1¼".
NEWTONIAN EASY-GUIDER **$139.50**
3X Relay Diagonal [See Photo] **$59.50**
Illuminated reticle eyepiece system . **$59.50**

CASSEGRAIN EASY-GUIDER™

For C-8, Meade 2080, Dynamax-8. Includes 50mm achromatic lens for f/5.8 operation-3X shorter exposures! **Superb rich field viewing, too!**
CASSEGRAIN EASY-GUIDER **$199.50**

GIANT EASY-GUIDER™

For Celestron-11, C-14, and the 10" Meade 2120. Includes 80mm clear aperture achromatic lens for edge-to-edge illumination & pin-point star images. F-ratio adjustable f/4-f/11. **Also yields unmatched Rich-Field viewing.**
GIANT EASY-GUIDER **$359.50**
48mm DEEP-SKY Filter ordered with any EASY-GUIDER [SAVE $20] . . . . . . **add $79.95**

WHAT DO YOU NEED?

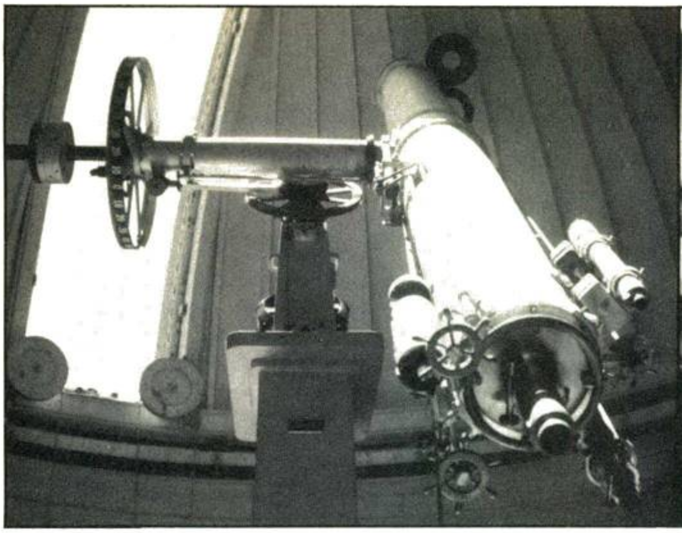
1. Hypersensitized Film. Use a LUMICON HYPER-KIT to insure a fresh supply, or use film pre-sensitized by LUMICON.
2. LED Illuminated reticle eyepiece system and battery pack, dual crosslines . . . **$59.50**
3. Telescope with good drive. (See above)
4. Piggyback adapter (state telescope type)...**$25** Deluxe adjustable **$39.50**
200mm f/3.5 multicoated lens **$99.95**
5. Filtration is essential for all lenses. Use hypered 2415 and the H-Alpha Pass Filter. For III a-J or color, use the Minus Violet Filter or the LUMICON DEEP-SKY Filter.
6. Off-axis guider is **essential** for consistantly good prime-focus astrophotography.
7. Dual-axis drive corrector and electric declination (state telescope type) **$259**

Kodak
TP 135-36
FUJICHROME
400
Kodacolor VR
1000
12

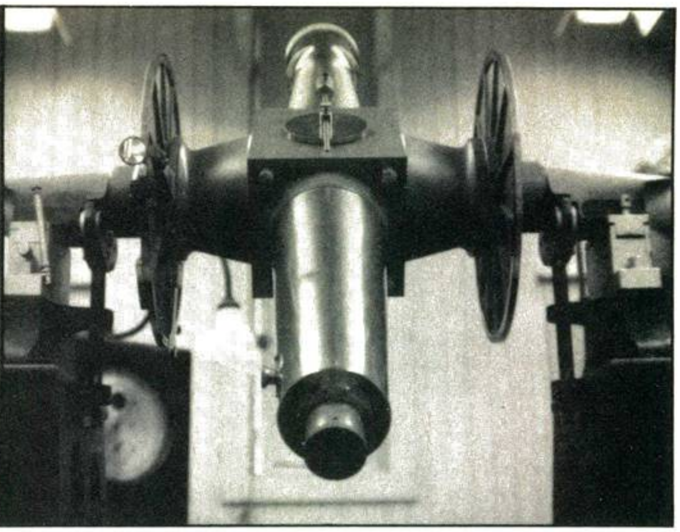
HYPERSENSITIZED FILM

LUMICON Hypersensitized film is essential for good deep-sky astrophotography. For fine grain B&W film use 2415. The fastest color films are Fujichrome 400 for slides and Kodak VR1000 for prints. Use VR1000 for galaxies and Fujichrome 400 for nebulae.

Film Type (35mm unless marked)	Exposures	Price
2415, Ultra-fine B&W, red sens	36	$9.95
Ektachrome 200 prof. 5036	20	$9.95
Fujichrome 400, "Excellent"	20	$12.95
VR1000, fastest of all, color negs	12	$12.95
5072, color slides from negs	36	$6.95
D-19 B&W Developer, 1 gal.		$5.95



20-inch Brashear refractor.



4-inch Fauth transit telescope.

Photos by Norman Sperling.

nearby sliding-roof observatory, a modern 9.5-inch refractor shows crisp, clear views. And beside it stands a 16-inch Newtonian, built by William B. Dublin. Perhaps he donated it to put in a good view for reflectors, since Chabot is so well endowed with refractors. Its aperture is large enough to rank second at Chabot.

The prime instrument is a glorious 20-inch refractor, in continuous use since 1916. The superb Brashear optics ride on a firm Warner and Swasey mount. Every clear Friday and Saturday night the public troops up for a look; admission is guaranteed free by Anthony Chabot's bequest. Few clubs can boast such a grand instrument, and fewer still can supplement one with such a splendid array of other telescopes. Qualified members conduct their own observing projects with the 20-inch Brashear — occultations, variables, and so on. Despite light pollution, the Brashear easily reaches magnitude 15.6. Relocated farther up in the hills, with new electronic detectors, it could perhaps reach magnitude 19.

The observatory's top floors hold more than the Clark and Brashear scopes. Two wonderful libraries (one for the school system, one for the club) are packed with classic books, periodicals, and observatory annals. Several club members use this resource to delve into the history and philosophy of astronomy. Downstairs, under the Brashear, there's an exhibit room that offers computer terminals, a seismograph, and a cast of California's huge Goose Lake meteorite (the Smithsonian has the original). Inside the telescope pier, a vault preserves historic and valuable glass plates from the early days of Lick Observatory. A couple of rooms away is the century-old Fauth 4-inch transit telescope. Originally a time standard for Oakland, it is now a gleaming brass memento of yesteryear.

Any facility featuring both a planetarium and an observatory would certainly rank in the forefront of American amateur astronomy. I thought so even before I understood the importance of the Telescope Makers' Workshop. That turns out to be the foremost amateur telescope-making group in the West. Every year, instruments made at Chabot impress the judges at Riverside. For three hours every Friday night, Paul Zurakowski and his team of telescope makers offer free coaching. Most members begin with 6 or 8-inch mirrors, but at Chabot, even a 16-inch stimulates only a passing comment. It takes an aperture of 20 inches or an unusual configuration like a Schiefspiegler to become the most-discussed grinder. As in most telescope-making shops, the best, most advanced, and most famous members help every beginner cope with the fundamentals of glass, grit, and pitch, as well as setting up the lathe or the Foucault tester. The telescope makers come from the entire Bay area. Leaders of nearby clubs are such regulars that it is common to hear them discuss operations of clubs an hour's drive away.

Of course, the Eastbay Astronomical Society conducts its own meetings at Chabot. Formed in 1924, it was partly begun as a citizen's group to protect the observatory. Eastbay is a world-class club, right up there with Ottawa, Lehigh, and Sabadell, with Grand Rapids and Bologna. What makes the club and the observatory it tends so special is the scale of the projects and the number of projects that attract enough people to get done.

Protecting the science center from potential budget cuts by the impoverished school board demands vigilance. Coordinating the observatory's planned relocation — up to a park farther from city lights — has required design, construction, and political savvy. Fostering the computer group's dramatic growth has also taken its share of the club's attention.

Most schools that can claim a "computer lab" operate one or two micro-computers (or perhaps a mini) headed by a faculty supervisor. In typical Chabot fashion, the computer lab features 14 terminals hooked up to two mini-computers, as well as five micros. A recent donation of a large mainframe allowed the astronomical society to convert it into yet another computer system, tailored to capabilities the users want. Some computer group regulars may soon tackle astronomical problems too large for personal computers — problems that require the megabytes of capacity that Chabot's computer lab affords.

Meanwhile, other members use equipment on loan from Lawrence Livermore Laboratory to monitor air pollution. Combining a telescope, spectroscope, and computer, they analyze light from a beacon on San Francisco peninsula, 20 miles west across the Bay.

The exceptional is the rule at Chabot. During the December '82 lunar eclipse, one member timed more than 50 occultations with the Brashear. Over the years, Chabot people have received half a dozen Bruce Blair medals as well as five other major awards. It was here that Doug Berger thought up Astronomy Day, now an international celebration.

Chabot attracted me so much that when I got the chance to move west, I picked a house nearby. But see it for yourself. Planetarium shows run at 7:30 p.m. every Friday and Saturday during the school year; the Brashear, Clark, and sliding-roof telescopes are open those nights, too. Eastbay Astronomical Society holds its lecture meetings on the first Saturday each month at 8 p.m. — come early for snacks.

Norman Sperling
Oakland, CA

SPACE 84

The Calendar of Space Art and Photographs
from the Creators of ASTRONOMY Magazine

BRING THE WONDERS OF SPACE TO *YOUR* WORLD!

- *13 exciting new images including:*
  - *— dramatic photos of celestial wonders*
  - *— paintings by today's finest space artists*
  - *— colorful NASA photographs*
- *11⅞″ x 11⅞″*
- *Spiral bound for hanging now, framing later*
- *Important dates in astronomy, celestial events and holidays*
- *Lunar phases shown*
- *Ample space for notes and appointments*

SPACE 84
JUNE 1984
NOVEMBER 1984

GIFT IDEA!
Buy 3 Calendars for $19.95
Get a 4th FREE!

SPACE 84 $6.95

Foreign orders add $1.50

To order, use the AstroMedia order form bound into this magazine, or send to AstroMedia Order Dept., P.O. Box 92788, Milwaukee, WI 53202.

Meet the people who help us reach for the stars...

THE BAUSCH & LOMB ASTRONOMICAL ADVISORY COUNCIL

When a company is truly dedicated to manufacturing only the finest products, they must reach beyond normal standards of evaluation. The name Bausch & Lomb enjoys a worldwide reputation for optical excellence, but rather than rest on past laurels, we rely on a team of leading authorities in the field of amateur astronomy to provide us with expert and objective guidance.

The Advisory Council serves as a valuable link toward fulfilling the needs of our customers, and as testimony of our continued dedication to astronomy.

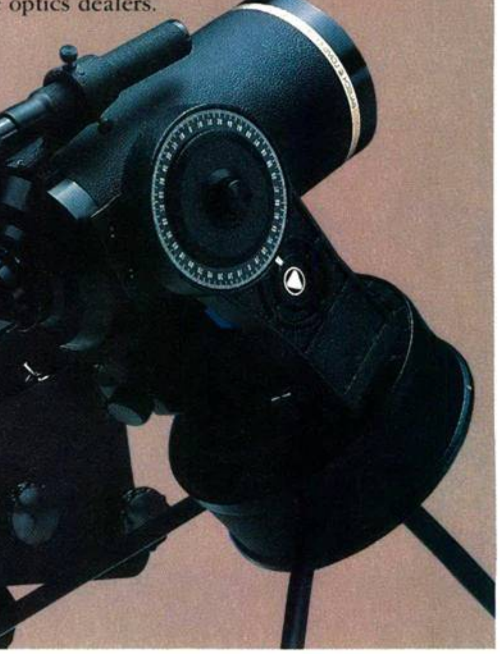
Ralph Dakin
Retired Bausch & Lomb Optical Engineer. The famous Dakin-Barlow lens is a product of his fertile mind.

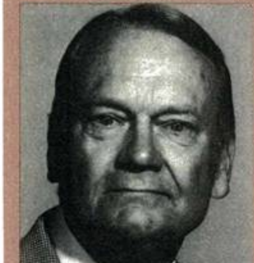
Mary Firth
Expert astronomer and astro-photographer with over 20 years experience. She is a board member and co-founder of the famous Polaris Astronomical Society.

George Keene
On staff at Eastman Kodak, Rochester, NY. Senior Engineer on LANDSAT project. Expert on telescopes and astro-photography. He authored the book "Star Gazing With Telescope and Camera."

BUSHNELL
DIVISION OF **BAUSCH & LOMB**
2828 E. Foothill Blvd Pasadena, CA 91107 (213)577-1500

Shown:
Bausch & Lomb Criterion "8000" and "4000" Astronomical Telescopes.
Available at fine optics dealers.

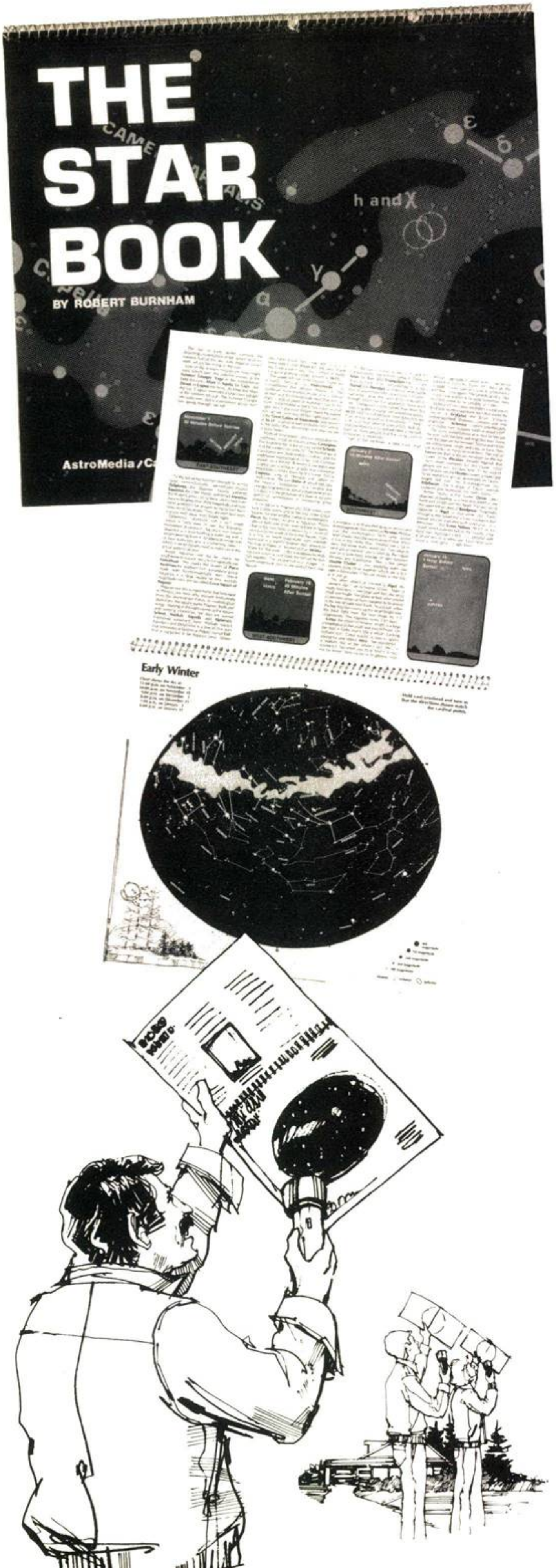




Richard Nelson
In the early 1960's he founded the Optical Craftsman Company which manufactured the highest quality reflecting telescopes. He is an expert on the heavens.

Fred Espenak
A professional infrared astronomer with NASA, also an accomplished "amateur" astronomer and astrophotographer. Along with George Keene, he leads solar eclipse tours.

William Douglass
Retired Pan Am Flight Engineer. President of Southern Cross Astro Society, in Miami, Florida. Expert amateur astronomer. Specializes in solar research.



Learn the Constellations with

THE STAR BOOK

from AstroMedia!

You asked for it — and we heard you!

Thanks to your requests, we are able to offer ASTRONOMY's popular STAR DOME maps in durable book form. And it's a dandy! We've spared no effort to insure that **THE STAR BOOK** will give you years of useful service. First, we printed it on robust 14-point cardstock, then coated the pages with a durable water-resistant varnish to withstand dew and dampness, and finally bound it with a sturdy metal-wire binding.

The maps themselves are the same maps you see each month in ASTRONOMY's Eye on the Sky department, reproduced in deep blue and black with white stars for maximum clarity. Constellation names and outlines shown in pale gray; all major stars named; naked-eye and binocular galaxies, clusters, and nebulae are identified.

Eight maps provide enough overlap for easy identification of prominent star patterns. A concise and lucid description of the stars, the constellations, their lore and legends by ASTRONOMY's Robert Burnham accompanies each map.

Preserve your collection of ASTRONOMY — no more torn-up magazines, no more soggy pages — treat yourself to a copy of ***THE STAR BOOK!***

- ***perfect for family outings!***
- ***eight charts cover all seasons***
- ***all northern constellations shown***
- ***easy to use at night***
- ***folds back for your convenience***
- ***printed in two colors on thick cardstock***
- ***durable heavy-duty spiral binding***
- ***will give years and years of service***
- ***measures 10″ x 11¼″***

$6.95
postage included

Foreign orders
add $1.50

Yes! Send me____________copy(ies) of **THE STAR BOOK** at *only* $6.95 each.

Name ____________________

Address ____________________

City ________ State ______ Zip ______

Allow 6 to 8 weeks for delivery.

AB-9-4

Send this coupon or a copy to AstroMedia Order Dept., P. O. Box 92788, Milwaukee WI 53202 — or use the handy AstroMedia order form bound into this magazine.

ASTRONOMY
IN FOCUS

Martian Property

Sir / "The First Martians" by Bruce Cordell (March '83 ASTRONOMY) failed to present a major issue: Since we have yet to answer the question of life on Mars, I feel no settlement should be seriously considered until we know if Mars has life or not.

This is so important because if life *were* found, I'm afraid of what might happen. To quote Carl Sagan, "If there is life on Mars, I believe we should do nothing with Mars. Mars then belongs to the Martians, even if the Martians are only microbes. The existence of an independent biology on a nearby planet is a treasure beyond assessing, and the preservation of that life must, I think, supersede any other possible use of Mars." The point is clear: We have no right to harm a world that doesn't belong to us.

If and only if we find Mars completely lifeless could we then proceed to plan missions such as the article suggests.

Marilyn Scholle
Brooklyn, NY

Who's Threatening Whom?

Sir / Re Mr. Port's letter in your July issue: typical Labor Party drivel. The U.S. is the world's greatest threat to peace? Indeed! Let Mr. Port ask a Polish citizen about the relative merits of NATO and Warsaw Pact alliances.

There are worse things than for international rivalry to be expressed in the form of competitive space exploration. Better the West and East try to prove the superiority of their systems by sending probes to the planets than by shooting at one another.

Greg Costikyan
New York, NY

Sir / I just couldn't let Mr. Port's letter on the Mars-grabbing schemes of the U.S. go unanswered. I can usually sit back and enjoy the lively give-and-take in In Focus, but Mr. Port's statement, that we are the "greatest threat to peace and civilization" in the world today, cries out for rebuttal. I'm certain Mr. Port would find a lively discussion of his views in Afghanistan and large areas of Cambodia, Poland, and Czechoslovakia.

Further, I think the representative governments in the European Economic Community would disagree with his contention that "most of the western world now condemns moves made by the U.S. in the world theater." Perhaps the horizon of his "western world" is a bit closer to his telescope mount than is desirable for an unimpeded view. Or maybe his "seeing" is not all that it could be.

I share Mr. Port's hopes for a cooperative effort to explore our solar system — the ESA Spacelab is an excellent example. I'd like to see ASTRONOMY continue as a forum on the space effort, especially to increase ties around the globe among interested readers. But I deplore a trend toward name-calling. Invective is a poor substitute for intelligent discussion.

Thomas D. Jones, Capt.
Ft. Worth, TX

Sir / Oliver Wendell Holmes once said that there is nothing in the U.S. Constitution that forbids the American people from making fools of themselves. Apparently he spoke not only of a purely American phenomenon, but of a human failing as well, for John Port's letter in the July issue was a political treatise of almost amusing pretensions.

Mr. Port takes to task Bruce Cordell's Mars article (March 1983) for having an American-centered view. He tries to explain his attack by asserting that the U.S. is the greatest threat to world peace, and asks, my goodness, what will happen if we "move the game into space."

Well. Let's put aside the fact that Mr. Port did not address the statements of Mr. Cordell over which he was so exercised — i.e., that the rest of the world would see a Mars landing as a triumph of the will of a democratic people. Mr. Port doesn't comment on this. Why the U.S. is the greatest threat to world peace, when this century's history clearly shows otherwise, he doesn't explain. Why American space successes are dangerous, when we claimed the Moon not for America but "in peace for all mankind," he also doesn't say.

Why is it that he fears America's space program, when Voyager pictures were distibuted for rebroadcast by radio amateurs at JPL, and thus made available to everyone? Why does he feel that American accomplishments in space demand that "other nations will lie down on their backs and bare their throats in defeat"? He does not say.

In fact, Mr. Port's argument is mush, born of anger — and this in a letter that exalts cooperation. Physician, heal thyself, and join the space effort instead of howling at it.

Mr. Cordell's argument was logical and without the taint that Mr. Port thinks he sees. Who else has been to the Moon? The Shuttle works; Ariane doesn't — at least not very well, so far. Mr. Cordell may not be right in presuming that the first Mars bases will be American, but he is not to be castigated for making an entirely logical conclusion. America can do it. The only question is, will we?

Earth is not Utopia, and the problems of Earth will no doubt go into space with the inhabitants of Earth. This is hardly the fault of America, but rather of the species which was fighting among itself long before there was an America. Until we can resolve this problem, we humans can do no better than to do our best to open space "in peace for all mankind," as we, America, have done. Scotland is welcome to join, and if I should meet Mr. Port on Mars, I shall be pleased.

Craig Smith
Milton, WI

Mars Exploitation?

Sir / Why are Aletha Biedermann-Wiens and Chris Boaden (In Focus, August) so angry with the human race and America respectively? Ms. B-W apparently hopes that Mars will never have a safe atmosphere, thus protecting it from exploitation. Personally, I am on the side of mankind, and hope that neither scientist nor "exploiter" is killed off by the hostile environment of Mars. Also, what's wrong with cowboys and alfalfa?

And, Mr. Boaden, if the U.S. in 1942 had been more interested in space travel than military force, your personal history might have taken a very different course. Maybe your "down under" location really does give you a peculiar perspective — perhaps you and Ms. B-W should get together and form the Mars branch of Greenpeace.

Steven K. Bidleman, M.D.
Klamath Falls, OR

A Happy Surprise!

Sir / We were happily surprised to find in the July issue of ASTRONOMY a new Southern Sky Almanac and Star Dome.

My son and I are very enthusiastic about your new approach and consider it useful for amateurs down here. We immediately shared the new feature with our local astronomy club.

We hope that this is to be a permanent change.

Gustavo and Carlos Dupetit
Boulogne, Argentina

Meteor Watching

Sir / In early June, while observing double stars in Lyra, I was surprised to see a faint orange meteor. I had heard about the June Lyrid meteors, but I hadn't expected to see any as it was before the peak and the shower was small and faint. Observing the area a day later I saw two more Lyrids — a faint white meteor and a brighter white one. As I have never seriously observed a meteor shower, I was very lucky to see the June Lyrids. This convinced me to try for the Perseids in August. But unfortunately, it rained for a week and a half at their peak. Well, I'll try again next year!

Elisha Polomski
Scituate, MA

Massless Confusion

Sir / The letter from Guy Rodrigue (In Focus, September 1983) asks how massless particles such as neutrinos can exert a pressure, since without mass they cannot impart momentum.

Your answer entirely missed the point. As I understand it, the term "massless" refers to particles such as photons which, theoretically, would have zero mass at rest. But such particles must always move at the speed of light while they exist. They therefore have energy and, since energy and mass are equivalent (from $E = mc^2$), they have mass and momentum.

Neutrinos may or may not be "massless," but in either case they have transferable momentum.

David Reiskind
Conshohocken, PA

IUS, TDRS-A, & OSTA-1

Sir / David Morrison's article on planetary exploration in the September issue was interesting and informative, but I noted two errors. The failure of the IUS to place TDRS-A in its proper orbit in April was not the first flight of the IUS. That took place on October 30, 1982, when it put two defense satellite communications systems (DSCS) spacecraft into geosynchronous orbit after being launched by a Titan 34D from Cape Canaveral.

The second error concerned the imaging radar carried by the Space Shuttle. This instrument was part of the OSTA-1 payload carried on the second Shuttle flight in November, 1981, not on the third Shuttle flight.

Thomas M. Faber
Hampton, GA

behind the scenes

The Milky Way by Bart Bok

Tucked away in the 523 section of the overheated reference room in the Ferguson Library, I found a wonderful book. I was 12. The book was a book about the Milky Way. Between its covers were words about stars and spiral arms, and magnificent photographs of stars so crowded together that in places the page looked solid white with them. That was also the year I got my first pair of glasses and discovered that I could see stars in the sky, too. Over the years, I took that book out again and again, savoring its clear prose and learning about our Galaxy.

On the way home, three days after the solar eclipse last June, I was looking in the shops along the main concourse of Singapore International Airport and had, to my delight, spotted copies of ASTRONOMY on a newsstand, when suddenly someone with a Dutch accent called my name. I turned — and there stood Bart Bok, grinning! Like me, he was on his way back from Indonesia having seen the solar eclipse. He was delighted at having beat the odds and seen the corona in a perfectly clear sky comfortably seated in a chair on the tennis court of the hotel.

Over a drink, we talked. He asked if I had liked the article he had sent in. I said it was fine. We agreed that he would send some additional pictures for it when he got home. We talked about another article to follow it; he was excited about the Magellanic Clouds and wanted to write about them.

Then the nurse/attendant brought his wheelchair. "They make me ride in this *thing*," he said, "for my heart," and finished his drink in one gulp. He looked straight at me: "I follow your magazine very closely," he said; "there is none better." The attendant gave me a grin and he was rolled away.

Bart Bok wrote *The Milky Way*. There is no way to know how many children have seen his book and, as I had but in their own ways, have made it part of their lives. He had a gift for communicating and a broad perspective that is not universal among scientists.

At Stellafane, in early August, David Levy told me that Bart had died, peacefully, of a heart attack, at home in Tucson. David was Bok's friend and biographer; they had been working on the biography together for several years. Surrounded by the telescopes atop Breezy Hill, a place haunted by the ghosts of astronomers, neither of us knew what to say.

Sincerely,

Richard Berry

Richard Berry
Editor-in-Chief

WE LOAN CELESTRONS WITH NO DEPOSIT!

SOME REASONS WHY YOU SHOULD MAKE US YOUR FAVORITE CELESTRON TELESCOPE DEALER

- We think our customers are just as honest as we are so we accept personal checks and ship scopes immediately from our large stock without waiting for the checks to clear. Our friends think we are crazy but we feel that a reputable mail order business should be based on trust. You trust us so why should we not trust you? We give you personal service both before and after you order.
- We resist selling you what you ask for if we feel it is not appropriate for your current skills. We specialize in helping beginners choose the correct equipment and accessories.
- We know the Celestron line almost as well as the manufacturer since we have units in daily personal use.
- We know the strong and weak points of all commercial scopes. Maybe some scope other than a Celestron is best for you — if so, we will tell you.
- We have developed a line of unique Custom Engineered accessories for Celestron telescopes so they will operate with less hassle when fitted with them. NO GIMMICKS — all made to help the beginner.
- **DON'T BE AFRAID** — Our Mail Order shipments to any place in the world are shipped in special scope containers. If by remote chance the scope arrives damaged we ship you a new one and WE handle the claim with the shipper — YOU don't. **WE EXPORT SCOPES WITH ANY VOLTAGE AND FREQUENCY FOR EITHER HEMISPHERE.**
- Do you feel the need of an astronomical friend? Call me. I would be glad to help you. I love astronomy and wish everyone did.

Roger W Tuthill

A BASKET FULL OF SOLUTIONS TO END YOUR FRUSTRATIONS!

"'Do these troubles sound familiar???"

You have a problem finding things in the sky; you have difficulty finding the pole easily and quickly; dewing stops your viewing; your scope vibrates too much; you would like to view with both eyes at once; you have trouble and need tools to collimate your finder and then you can't see the crosshairs in the dark and your finder is too small to see things anyway; you would like to use your setting circles but can't hold a flashlight to see them and move your scope at the same time because you do not have three hands; you wished you had a permanent mounting; you have trouble getting accurate focusing; your R.A. knob adjustment is too sensitive; you waste valuable observing time thinking you need to level your tripod; you have trouble using your scope to see stars or planets in the daytime.

Rest easy friend—we can help you. We have been down that road, too. So we have designed a specific product that solves each problem mentioned above in order to make your astronomical activities as satisfying as they are supposed to be.

To get a detailed description of these great products and others send for our FREE catalog or see offer below.

These practical products are the result of our 24 years of amateur astronomy experience in this field. This hobby is supposed to be rewarding but unfortunately many times it turns out to be a hassle and is a disappointment.

Recognized As Headquarters For Telescope Solar Filters
Solar-Skreen® Sun Filter

SOLAR SKREEN Sun filters (USA Patent #3,897,140) fit all scopes and use no glue or magnets. Double aluminum surfaces are shielded from damage. The fine qualities and SAFETY of this filter are described in detail by Dr. B.R. Chou in *Sky and Tel.* pg. 119, August 1981, and *Astronomy* Review, March, 1982 pg. 75.

The whole of the United States and adjacent countries will experience another eclipse of the Sun on May 30, 1984. NOW IS THE TIME TO GET READY for this event. Do not wait till the last minute. You can observe it with our LOW-cost Hydrogen-Alpha filters.

We have developed a special Solar Skreen filter for this event, which can be sold by local clubs or planetariums as a fund-raising means. Plan NOW, since we will not have a repeat for many years.

CELESTIAL NAVIGATOR Mk. III
16:41

THE MISSING LINK ANOTHER TUTHILL TRIUMPH

HIGH ACCURACY/LOW COST DIGITAL CIRCLES

The CELESTIAL NAVIGATOR MARK III consists of separate, independent, self-contained R.A. and Dec. units with built-in batteries good for any country in either Hemisphere. SEND FOR USER REPORT.

Call Toll Free:
1-800-223-1063

Send a LARGE (9"×12") BROWN Self-Addressed Stamped Envelope (2 oz.) of you want complete info including our new FREE catalog which illustrates all our unique aids to your great hobby.

Interested in a Schmidt Cass scope? We urge you to get a Celestron EVEN if you don't get it from us. You will be a lot happier with the optical perfection and proven performance.

WE REPAIR CELESTRON SCOPES
Master Charge, VISA *Trademark

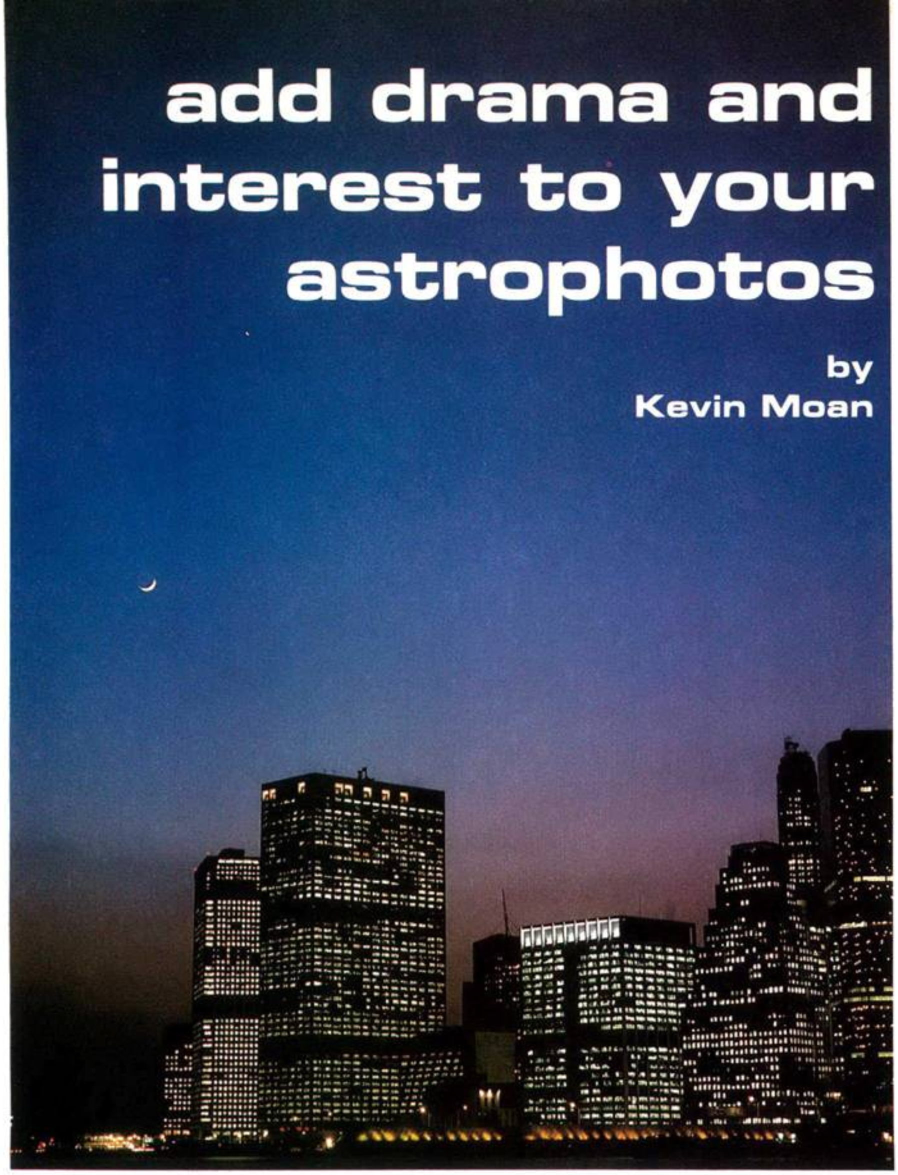
Telephone: (201) 232-1786

ROGER W. TUTHILL, INC.
11 Tanglewood Lane, Dept. A, Mountainside, N.J. 07092

add drama and interest to your astrophotos

by Kevin Moan

photography in astronomy



Taken 30 minutes after sunset, author Moan's photo shows the Moon and Venus in an indigo sky over a cityscape of office buildings. The exposure was 16 seconds on ASA 64 slide film.

Anticipating an appearance of Venus in the evening sky, I once watched a beautiful sunset over a long, low valley. As the Sun dipped below the horizon and the sky changed from orange to blue, I saw the crescent Moon, trailed by Venus, follow the Sun over the distant hills. Suddenly I was struck with a perception that has kept me enthralled with astronomy to this day.

Although I knew, intellectually, of the great distances separating these celestial bodies from the Earth, I was now aware of the great difference in distance between them. There lay the hills across the valley, the Moon beyond the hills, the Sun (just out of view) beyond them both, and Venus beyond them all. That night I parted company with all the ancient peoples who thought of the sky as a great dome above us. For the first time, I really *saw* the heavens as three-dimensional space.

Since that evening I've tried on many occasions, with some success, to take photographs that suggest this feeling. I'm now convinced that the key to enlisting the imagination of the viewer, to suggesting that vital third dimension in a two-dimensional photograph, lies in providing good foreground detail. This simple factor can turn a standard view of the planets — a conjunction of the Moon and Jupiter, say — into a photograph that makes the viewer feel much of the awe the event itself inspires.

By including in the frame a silhouette of an interesting bridge, a windmill, or a tree — or even by showing a city skyline in the foreground — you invest your photograph with an amazing amount of visual power. Foreground detail helps to pull the viewer's eye into the photograph, where additional detail will carry it even further.

Obviously, not all sky events will be convenient. A beautiful lunar eclipse may occur with the Moon high and lonely in a midnight sky, far above anything you could squeeze into the frame — or the best moment of a close conjunction may come before the objects rise over your eastern horizon. Great photographs are made, however, they don't just happen. Planning is essential. Be on the lookout for upcoming events and allow yourself several weeks to prepare. Check the Eye on the Sky and Sky Almanac sections for likely subjects, or work out future lunar and planetary positions yourself with the help of the *Astronomical Almanac* and computer/calculator programs.

The basic requirements call for an event that can be seen within 30° to 40° of the horizon shortly after sunset or before sunrise. That time of day will give you enough light along the horizon to silhouette buildings or mountains, and the elevation limit will enable you to place a portion of the landscape into the frame using camera lenses of typical focal lengths.

Right: Just before sunrise on October 15, 1982, Dewey Vanderhoff photographed the Moon and Mercury against a dawn sky colored red by dust from the El Chichon eruption.

Far right: Venus and the Pleiades shine behind an 84-foot radio telescope. Peter Alway used light from a Full Moon to help illuminate the scene and color the sky blue; the equipment was a 50mm lens and 400 ASA film.

When there's no one critical moment for an event (and this is fairly common), the best time to shoot is when the Sun lies about 20 minutes below the horizon (look up the times of sunrise and sunset in the newspaper or derive them from the tables in the *Almanac*). At this time of day the sky brightness is just about equal to that of the landscape. The light is sufficiently dim to let you give an exposure long enough to record any lighted buildings without overexposing the sky and washing out the objects of interest. It is also the time of day when the sky takes on a beautiful rich blue that makes an attractive contrast to the gleam of the planets.

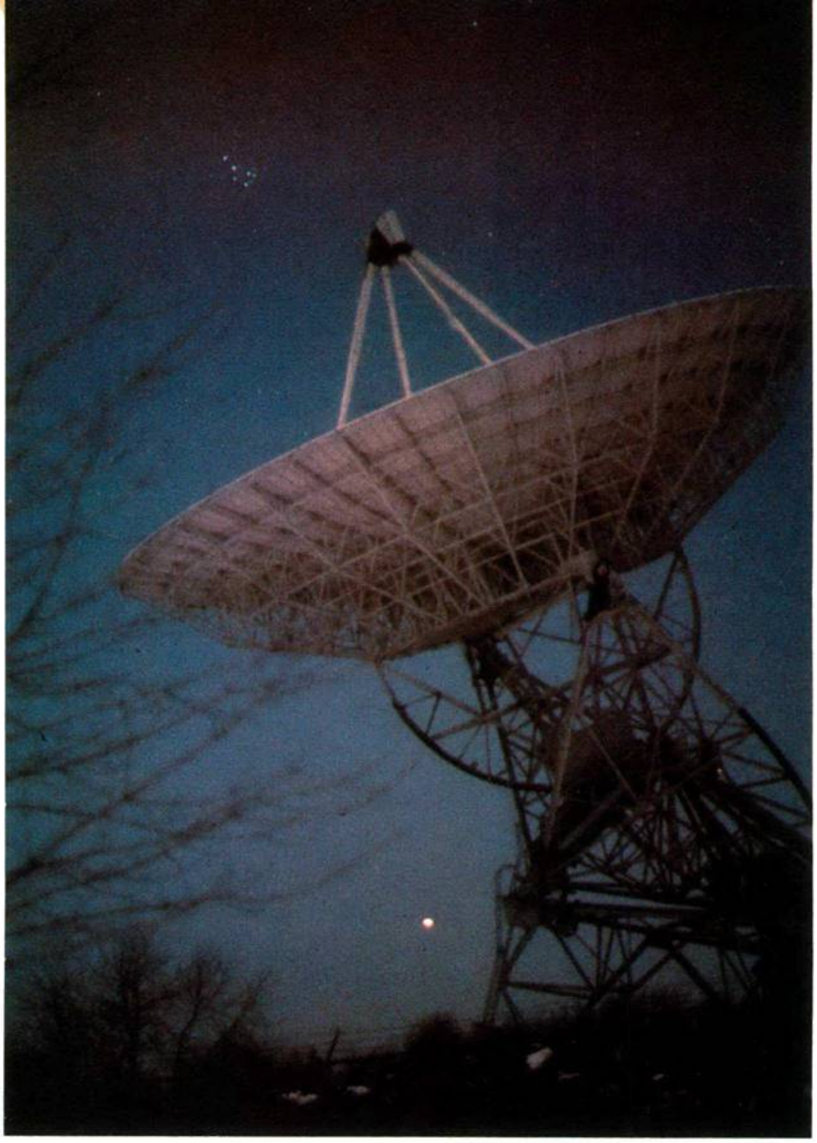
The magnitude of the celestial object is important when you photograph in twilight. A magnitude of -3 or brighter will put a clear image on film, but you can get away with photographing objects down to about -1 magnitude in most twilight shots. For events that take place in full darkness — and these can also be spectacular — the lower limit for brightness is several magnitudes fainter still.

The location you select has a lot to do with the success of the ultimate image — in fact, the setting of the photograph is just about as important as the celestial event itself. The ideal site is accessible, provides a good view of a landscape or a landmark feature, and isn't too close to extraneous bright lights or the headlights of passing vehicles. You probably know where the prime scenic views in your area are, but if not, look over some souvenir post cards or do a little advance scouting. Be on the alert for good vantage points and get to know your area well.

Once you have a general idea of a location, a detailed map can be an invaluable guide to finding the ideal spot. Street maps will show you where the open areas in cities are, like parks and vacant lots. Topographic maps (try the public library) are also an excellent source for locating high vantage points and well-placed churches, bridges, towers, or hills.

When you have decided on the event you wish to record and the spot to shoot it from, go there a week or two ahead of time and do a series of photos at the same time of day as a dry run and an exposure test. This is time well spent, since you probably won't get a "return engagement" of a particular conjunction for years — or even decades — to come. (This is also the best time to find out that that picture-perfect high ridge facing west now includes a new condominium complex that destroys the view.)

For sunset shots, arrive at the location before sundown. This saves you the hassle of stumbling over unfamiliar terrain or misplacing your equipment in the dark. (Of course, if the event occurs at dawn, you'll have to set up at night — but that's when your advance scouting pays off doubly.) Since exposures will probably run at least a second and often more, you will need a good sturdy tripod. Set it up so that it is rock-solid, level, and sheltered from the wind. If possible, use it only at minimum extension for better stability. Tie a heavy rock, weight, or old sock filled with dirt to the central post of the tripod if you want greater stability and less vibration.



Normal lenses are perfectly adequate in most cases (though you'll appreciate having a wide-angle, a telephoto, or a zoom for some events). Fifty-millimeter lenses have a field of view wide enough to include part of the landscape as well as the sky. They also have sufficient depth of field to keep both foreground and planets in sharp focus when set on infinity — an advantage denied the longer focal length lenses. (To be safe, keep any object in the foreground at least 100 to 150 feet away from you.) Normal lenses also reduce the streaking caused by the apparent motion of all celestial objects.

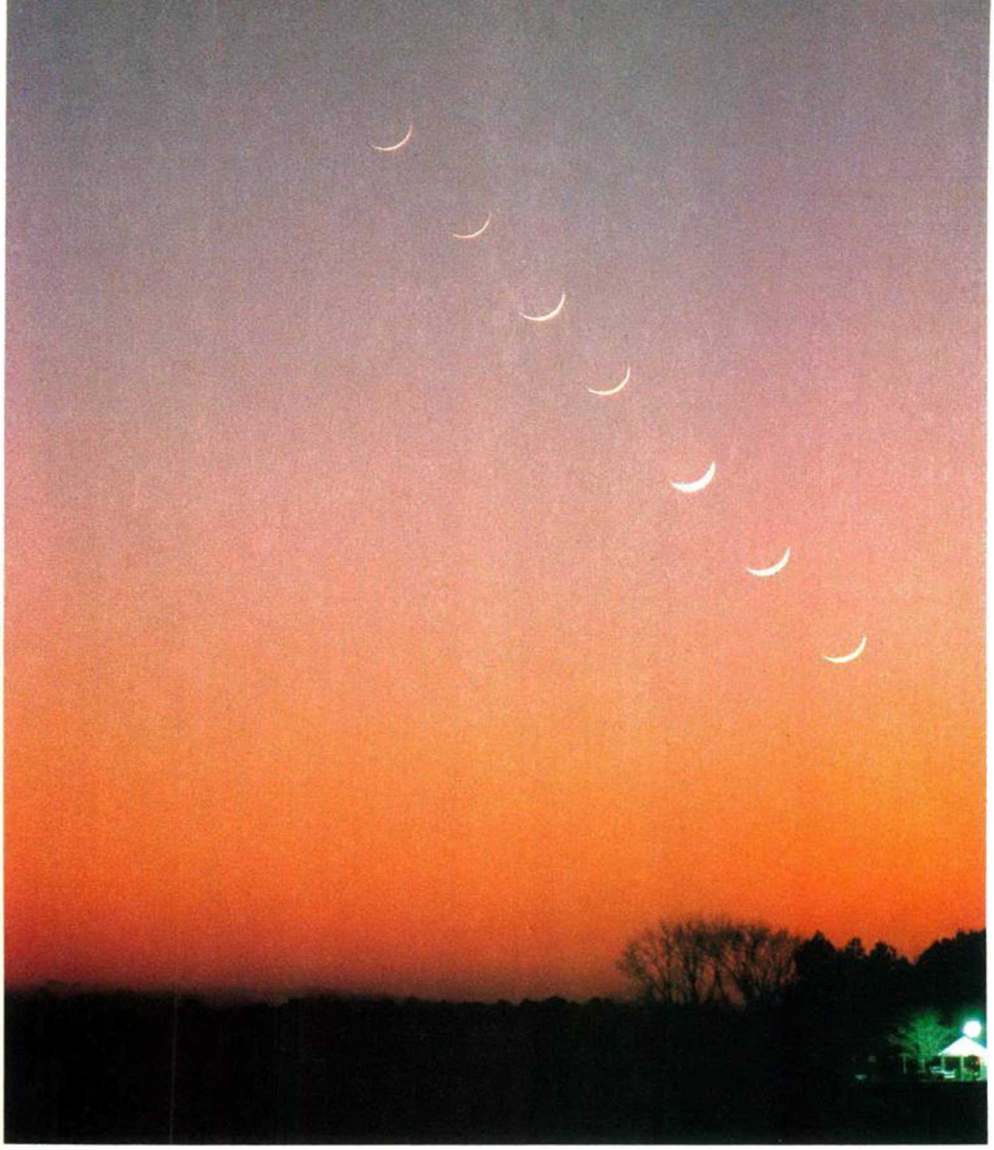
Mount the camera on the tripod and attach a cable release. Frame the composition in the viewfinder while there is still plenty of light. Take a good guess at where the objects will be after sunset; include that area of sky in the composition. If possible, try to include at least one of the celestial objects of the upcoming event. Look up its magnitude so that you can judge the relative brightness of the other objects when they appear.

Beware of nearby street lamps and parking lot floodlights. Keep them out of the frame — they look innocuous by daylight, but will become extremely bright after dark. If you include them, they'll badly overexpose the photo. Finally, check that the camera is level. Nothing makes you look sillier than an obviously level horizon — water, say — that isn't level in your photo.

For test exposures slide film works best. You'll want to know the effect of the different exposures you try. If you use negative film, the photo finisher will attempt to compensate for apparent over- or under-exposures, ruining your test. You need to see how the film actually records the balance of light between the landscape, sky, and objects.

I've found Kodachrome 64 to be excellent for both tests and "the real thing." It has extremely fine grain and is very sharp. In addition, its color saturation is also excellent — an important advantage in recording the subtle colors of a twilight sky. Yes it *is* very slow, and your exposures will last several seconds. But even if you used 400 ASA film, the exposures would still run too long to let you handhold the camera. So — since you have to use a tripod anyway, why not use a film that yields the best available quality? With normal or wide-angle lenses, celestial objects will not show streaking in under eight seconds and most twilight exposures will run less than that.

At this point, you're all set up and prepared, just as you will be for the real event. As soon as the Sun goes over the horizon, begin taking meter readings of the sky so that you get a feel for how rapidly the light is changing. When the proper time approaches, you may find it has become so dark that you have difficulty getting a reading on your meter. Switch the meter setting to a very fast ASA; you can then use that reading at the faster ASA to calculate the exposure needed for the film you are using.



The setting Moon and Mars on January 7, 1981, were the subjects of Michael Clark's multiple exposure photograph: He used a series of 2-second exposures spaced at 5-minute intervals, with a 135mm lens at f/2; the film was ASA 400. Mars is faintly visible to the lower left of the Moon.

For example, let's say you are using ASA 64 film, but darkness forces you to set the meter to ASA 400. It might then give a reading of f/4 at ⅛ second. At ASA 200 the proper exposure would be f/4 at ¼ second; at ASA 100 the exposure would be f/4 at ½ second. At ASA 50, it's f/4 at 1 second. This falls close enough and becomes your "base exposure." Using this as a starting point, you should bracket exposures by at least two stops up and down.

A cautionary note on the Moon: The Full Moon is very bright and, with 64 ASA film, requires an exposure of 1/60 or 1/125 second at f/4 in order to retain detail on its face. Longer exposures burn out the lunar disk totally. This means, for all practical purposes, that you can't get "the Man in the Moon" onto the same frame as your scenic foreground unless the Moon is near the horizon and there is enough haze or dust to dim it considerably. (You'd also need a long telephoto as well, to yield adequate image size.)

You may find you prefer an earthlit crescent Moon anyway, since its shape identifies it and its lower brightness makes it more compatible with planets in long-exposure photographs. And one more thing — take your skylight filter off before you shoot. If you don't, you'll get funny-looking and very annoying ghost images in every picture taken of the Moon or any bright planet.

With the set of exposures you determined, adjust the camera and shoot a full series every few minutes. Keep a log that records how long after sunset you took each shot and what the exposure setting was. This is essential for duplicating your best results after you get the photos back from the lab. When the slides come in, transfer the exposure log info to the slide mount of each photo. Then compare the results on a light-box or in a slide projector.

Scanning through them, you'll see a wide range of results. Some will be terrible, most "sort of O.K.," and one or two will just about knock your socks off. Pick out the time of day and the exposure combination that worked best overall. This becomes your new base exposure when you shoot the real thing.

Finally the great day arrives. The weather's perfect and out you go. Set-up is a cinch (practice makes perfect, after all!), and everything goes according to plan. You dial in your corrected base exposure and shoot several series, bracketing around the central value. Later, the shots come back from the lab and they're beautiful . . . magnificent! Even the duds look good. You eagerly show them to your family and friends and, somehow, you know you've connected this time. Finally, they *understand*. At last, they too catch a hint of what it is that drives you to look at the nighttime sky.

Kevin Moan is a commercial photographer in New York City; he has been an astrophotographer for many years.

ASTRONOMY REVIEWS

X-ray Astronomy

J. Leonard Culhane and Peter W. Sanford
192 pages, hardcover, $25
Charles Scribner's Sons (1981)

X-ray astronomy began in 1949 with observations of the Sun using captured V-2 rockets. Since then, sounding rockets have given way to satellite observatories. Aside from the Sun, astronomers have identified more than 150 strong X-ray sources within our own Galaxy. Some of these sources are best explained as neutron stars or black holes — the collapsed remnants of burned-out suns — that orbit around a main-sequence star.

Culhane and Sanford give a lucid overview of X-ray astronomy, from its history and nature to solar X-rays, supernovae and their remnants, clusters of galaxies, quasars, and observatories of the future. The book is somewhat technical; the publisher notes on the book jacket that it is the "ideal introduction" for both the student and the interested amateur.

Distant Encounters: The Exploration of Jupiter and Saturn

Mark Washburn
272 pages, paperback, $12.95
Harcourt Brace Jovanovich (1983)

To the scientifically ignorant public, first flybys of planets in our solar system seem like an esoteric ritual that scientists, but hardly anyone else, would bother to change the channel for. Second flybys count for nothing at all. Yet a small number of people, the potential audience for Mark Washburn's book, would have given nearly anything to be *there* when Voyager 1 and 2 swung past giant Jupiter and ringed Saturn and returned humankind's first intimate glimpses of these worlds. Washburn has captured and recorded what it was like to be there.

Washburn is not the first to detail the pressroom events surrounding the Voyager flybys of the giant planets. Two NASA books — *Voyage to Jupiter* and *Voyages to Saturn* — dwell on the scene in the pressroom. ASTRONOMY and other science magazines covered these events extensively, often with first-person, you-are-there writing about events almost maddeningly distant. Something about these flybys, these close encounters with gigantic distant worlds, has inspired an extraordinary response from journalists.

Washburn is unique, though, in having written about both the flybys and the scientific meetings that came between and followed the flybys, having written about the underlying fear that planetary missions were going to be cancelled, and having written of the scientists privy to the incoming data stream. Washburn captures that weird combination of excitement and boredom, suspense and ho-hum perfection, high adventure and ordinariness, of being part of things yet being excluded, that the working press experienced.

To this degree, if you are one of those people who would have given anything to be there *when it happened*, or even someone simply curious about what transpired during those two years when two fuzzy, telescopic blobs of light became two richly detailed planets circled by multitudinous rings and orbited by umpteen tiny and not-so-tiny moons, you will enjoy — and savor — Mark Washburn's book. He has succeeded in producing the "*record* of that odyssey, a *journal* of exploration and discovery" that he set out to write.

Where Washburn fails, however, is in his portrayal of scientists, JPL officials, and journalists — Brad Smith, Ed Stone, Frank Bristow, James Beggs, Jon Eberhart, Mitch Waldrop — as individuals. Though he describes a few peculiarities of hair or dress, attributes a few clever or peevish remarks to them, and even hints at the existence of personality beyond the superficial, the characters in this drama of space exploration remain cardboard cutouts. Perhaps it's an impossible task to portray individuals engaged in a mission involving so many.

Nonetheless, I cannot help but imagine how disappointed I would feel reading an account of another historic journey, that of Meriwether Lewis and William Clark to survey the new western territories, only to find the leaders, surveyors, scouts, and botanists of that expedition portrayed as cardboard functionaries of the great expedition. The pleasure and excitement of the journey would collapse under the weight of quotable quotes, expedition statistics, and new discoveries. After reading the book, I would know only that for them it had been an exciting trip, but would have failed to share their excitement myself.

Yet Washburn has done better than that. Some of the excitement *does* leak through: the boyish enthusiasm of scientists, the elitist, competitive atmosphere of press conferences, the raw shock at discoveries that can't be explained immediately. Perhaps the experiences that go beyond them just can't be written down. *Richard Berry*.

Lumicon Deluxe Super Finder Telescope

$199.50
Lumicon, Inc.

The Lumicon Deluxe Super Finder is an 80mm f/6.3 refractor that uses an air-spaced objective of 500mm focal length. So far as I can tell, these specifications are unique, and the telescope fills a definite "hole" in the commercial market.

Its base price of $199.50 covers the optical tube assembly only. You must purchase eyepieces, star diagonal, and mounting brackets separately at additional cost. Both a 1¼" and a 2" focuser are available; the 1¼" version uses a helical focuser, while the 2" model employs a simple slide focus. Although neither is as convenient as rack and pinion focusing, both are functional, with nylon thumbscrews making the slide-focus action quite smooth. The scope also comes with a dew cap and a mounting flange to allow you to attach it to a camera tripod.

Although the Deluxe Super Finder is intended for use as a finderscope for large telescopes, I have used mine as a small and portable general-purpose telescope. The length of the 1¼" version (equipped with a star diagonal) is only 16", so it fits easily into a suitcase. Using a 24mm Konig eyepiece, I get about 20x and a 3° field of view. Views of the Milky Way are magnificent — objects like the North America Nebula and the Veil Nebula stand out in excellent contrast, and the "tourist attractions" in Sagittarius are easy targets.

In terms of optical quality, coma is only slightly noticeable at the edge of the field, and overall image quality is surprisingly good at higher powers. Using a 9mm orthoscopic and a 2x Barlow (yielding 111x), I have been able to see structure in the jovian belts and the Great Red Spot and to follow satellite transits. Cassini's division in Saturn's rings is routine. Lunar views are also excellent; seeing the Triesnecker rilles poses no problem. Epsilon Lyrae is cleanly split. Although the scope gives some false color on bright objects at high power, it is not obtrusive and almost disappears when the seeing steadies. Stopping the aperture down to 2.5" is often helpful.

In short, I've found the Lumicon Deluxe Super Finder to be a very versatile small telescope with fine performance. Those seeking a traveling companion, needing a large finder for their big telescope, or employing the "phased approach" to amateur astronomy (see Forum, ASTRONOMY, June 1983) will find it a good value. *Robert Allen Buss.*

Frame of the Universe
Frank Durham and Robert Harrington
284 pages, hardcover, $24.95
Columbia University Press (1983)

Frame of the Universe focuses on the history of cosmology, with about two-thirds of the space devoted to pre-relativity models of the universe. The book is written for the layman and contains an overview at the beginning to provide the reader with the basic facts of astronomy.

Astrophysical Jets
A. Ferrari and A.C. Pacholczyk, eds.
327 pages, hardcover, $48
D. Reidel (1983)

Recent high-resolution radio, optical, and X-ray observations indicate that active astrophysical objects, from the nuclei of galaxies to star-sized sources, eject supersonic — and even relativistic — flows of plasma. These flows, or "jets," involve a substantial fraction of the energy available from their sources.

The Turin, Italy, Workshop on Astrophysical Jets, held in 1982, was organized to provide observers and theoreticians with an opportunity to discuss various proposals and experimental tests on these energetic outflows. This volume contains the proceedings of that workshop.

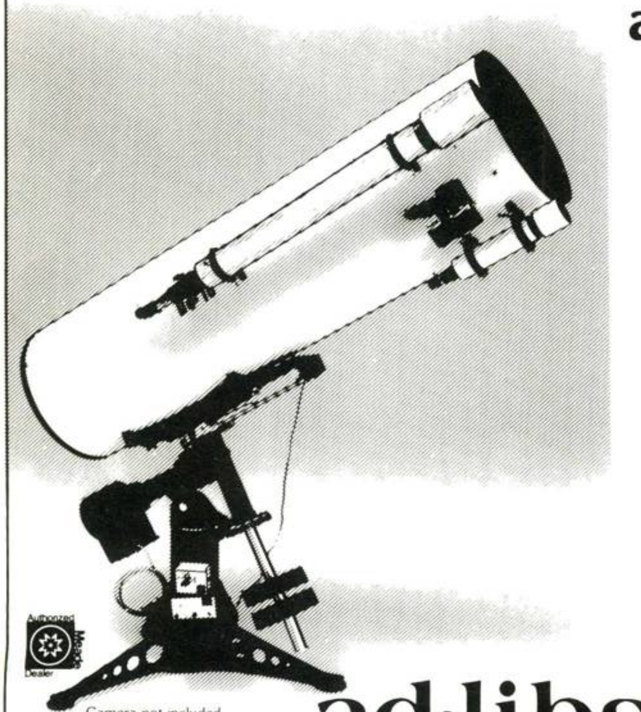
Violent Phenomena in the Universe
Jayant V. Narlikar
218 pages, hardcover, $19.95
Oxford University Press (1982)

In his preface, Narlikar remarks, "The one aspect about our universe that strikes the astronomer most is that the cosmos is not altogether as quiet and peaceful as the clear night sky would make us believe."

An astrophysicist at India's Tata Institute of Fundamental Research, the author discusses some of the most controversial topics in astronomy, including black holes, supernovae, active galaxies, quasars, and the Big Bang. Although the book is written at a popular level, Narlikar also uses boxed-off derivations and simple equations to clarify his discussion. "The purpose of this book," he writes, "is to present to the reader an account of some of the highlights of this violent universe and of the attempts by the astrophysicists to make sense of these observations."

Want out-of-this-world telescopes at down-to-earth prices?

We have what you want.



Camera not included.
Price with all options shown, $1640.45.
Prices good through 1/15/84.

At Ad-Libs Astronomics, we're in our fifth year of saving you money on top-quality telescopes and accessories — like the incredible 16" f/4.5 Meade DS-16, left. Our discount price on the basic DS-16 is only $1274.95, plus freight — and we'll save you money on all the options shown, as well.

Want some other savings? The Meade 2080 8" Schmidt-Cassegrain, with wedge, tripod, and more — $1405 list — is only $999, plus freight. Super performance, at a 29% savings! The Meade 10" 2120 — with wedge, tripod, all standard accessories — is only $1949, plus freight, a $621 savings!

And you save on every other brand we carry, as well! The Celestron Comet Catcher is only $297.50. Its unique equatorial mount is also only $297.50. Celestron's $284 list 11 x 80 comet hunting binoculars are only $199.95. Edmund's Astroscan 2001 is a low $187.50. The Bushnell 4" Criterion 4000 Schmidt-Cassegrain is only $489. You'll find savings like these on Celestron, Meade, Questar, Bushnell, Coulter, Edmund, Unitron, TeleVue, Lumicon, Brandon, University, and more.

Send a stamped, self-addressed envelope for a *free* discount price list showing your savings on more than 70 telescopes and 500 accessories, plus information on how to pick the right telescope. Or send $1 for our information-packed 36-page catalog. It takes the guesswork out of picking the right telescope and accessories — and saves you money, too!

ad·libs astronomics

2401 Tee Circle, Suite 106
Norman, OK 73069 (405) 364-0858
Now in our 5th year of saving you money! Mastercard, Visa.

High-Latitude Space Plasma Physics
Bengt Hultqvist and Tor Hagfors, eds.
543 pages, hardcover, $75
Plenum (1983)

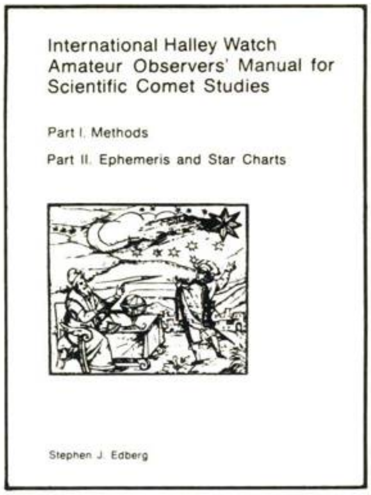
This volume presents recent research in the physics of the high-latitude ionosphere. The proceedings of a Nobel Foundation Symposium held in 1982, this collection covers magnetospheric physics between one and two Earth radii and how properties of the solar wind affect this region. Papers also describe the European Incoherent Scatterer facility in Sweden and the upcoming Viking project, a Swedish probe designed to study near-Earth space and scheduled for launch next year.

Astronomy Statement of Ownership, Management and Circulation

(Required by 39 U.S.C. 3685). 1A. Title of publication: ASTRONOMY. 1B. Publication No.: 00916358. 2. Date of filing: September 30, 1983. 3. Frequency of issue: monthly. 3A. Number of issues published annually: 12. 3B. Annual subscription price: $21.00. 4. Complete mailing address of known office of publication: 625 E. St. Paul Ave., Milwaukee, WI 53202. 5. Complete mailing address of the headquarters or general business offices of publisher: 625 E. St. Paul Ave., Milwaukee, WI 53202. 6. Full names and mailing addresses of publisher, editor, and managing editor: Publisher, Robert A. Maas, 625 E. St. Paul Ave., Milwaukee, WI 53202; Editor, Richard Berry, 625 E. St. Paul Ave., Milwaukee, WI 53202; Managing Editor, Katherine Bond, 625 E. St. Paul Ave., Milwaukee, WI 53202. 7. Owner: AstroMedia Corporation, 625 E. St. Paul Ave., Milwaukee, WI 53202, whose owners are David L. Walther, 625 E. St. Paul Ave., Milwaukee, WI 53202; Christopher Walther, Elizabeth Walther, Jennifer Walther, Jonathan Walther, Mark Walther, 625 E. St. Paul Ave., Milwaukee, WI 53202. 8. Known bondholders, mortgagees, and other security holders owning or holding 1% or more of total amount of bonds, mortgages, or other securities: none. 9. For completion by nonprofit organization authorized to mail at special rates (Section 423.12 DMM only): not applicable. 10. Extent and nature of circulation: 10A. Total number of copies printed (net press run): average number of copies each issue during preceding 12 months: 212,694; actual number of copies of single issue published nearest to filing date: 203,000; 10B. Paid circulation: 10B1. Sales through dealers and carriers, street vendors, and counter sales: average number of copies each issue published nearest to filing date: 35,864; actual number of copies of single issue published nearest to filing date: 35,864. 10B2. Mail subscription: average number of copies each issue during preceding 12 months: 121,839; actual number of copies of single issue published nearest to filing date: 109,533. 10C. Total paid circulation (sum of B1 and B2): average number of copies each issue during preceding 12 months: 157,703; actual number of copies of single issue published nearest to filing date: 145,397. 10D. Free distribution by mail, carrier, or other means of samples, complimentary, and other free copies: average number of copies each issue during preceding 12 months: 259; actual number of copies of single issue published nearest to filing date: 270; 10E. Total distribution (sum of C and D): average number of copies each issue during preceding 12 months: 157,962; actual number of copies of single issue published nearest to filing date: 145,667. 10F. Copies not distributed: 10F1. Office use, left over, unaccounted, spoiled after printing: average number of copies each issue during preceding 12 months: 1,096; actual number of copies of single issue published nearest to filing date, 3,697. 10F2. Return from news agents: average number of copies each issue during preceding 12 months: 53,636; actual number of copies of single issue published nearest to filing date: 53,636. 10G. Total (sum of E, F1 and 2 — should equal net press run shown in A): average number of copies each issue during preceding 12 months: 212,694; actual number of copies of single issue published nearest to filing date: 203,000. 11. I certify that the statements made by me are correct and complete. Robert A. Maas, Publisher.

PARTICIPATE IN

HALLEY WATCH !



International Halley Watch
Amateur Observers' Manual for
Scientific Comet Studies

Part I. Methods
Part II. Ephemeris and Star Charts

Stephen J. Edberg

Amateur astronomers! Don't miss the new book *International Halley Watch Amateur Observers' Manual for Scientific Comet Studies.* It is required reading for those who want to contribute data about Halley's comet.

Stephen J. Edberg has been named Coordinator for Amateur Observations for the International Halley Watch, the organization that is guiding the world-wide scientific effort to study the close approach of the comet in 1985-86. He has prepared a 192-page manual telling how to participate.

The manual describes techniques of observing comets and provides detailed information about six areas of study for Halley's comet: visual observations, photography, astrometry, spectroscopic observations, photoelectric photometry, and meteor observations. Nineteen star charts (reproduced with the permission of the AAVSO and the BAA) are provided showing the path of Halley's comet in 1985-86. There are an ephemeris, chapters on calibrations and standard stars, and forms for enrolling in the IHW and for making reports on Halley observations.

The standards for amateurs to use when observing the comet are rigorous. Get a head start by studying *International Halley Watch Amateur Observers' Manual for Scientific Comet Studies.* Order today.

To: Enslow Publishers
Box 777
Hillside, NJ 07205

INTERNATIONAL HALLEY WATCH
AMATEUR OBSERVERS' MANUAL
FOR SCIENTIFIC COMET STUDIES
by Stephen J. Edberg (192 pages, paper).

Please send me this book. A check or money order is enclosed

as follows: —— copies, @ $9.95= Total of $——.——.

Name——————————————————————
Address————————————————————
City, State, Zip———————————————————

eye on the sky

planetary alignment opens the year

by Fred Schaaf

the wanderers

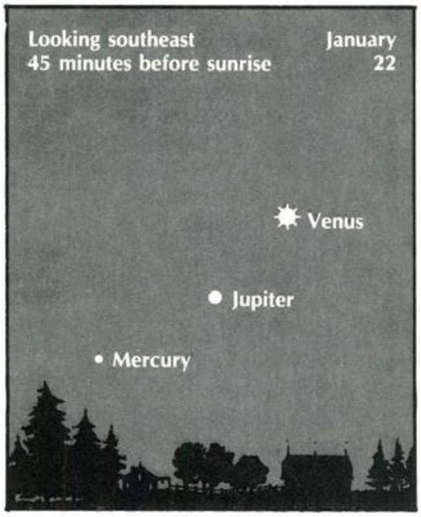
This month skywatchers get to glimpse a rare and exciting spectacle: an alignment of all the planets. During part of January 1984, the Sun's family of planets (except Earth) lies along a stretch of the pre-dawn ecliptic less than 70° long! As a result, there are several extremely close conjunctions, including the closest one observable in nearly two decades.

How does this month's arrangement compare with the famous alignment of February to March 1982, when it was possible to observe all the planets and even the four major asteroids in the same hour? You may recall that there was much popular concern over the supposed "Jupiter effect," predicted by John Gribbin and Stephen Plagemann. They claimed that an alignment of all the planets would, through a complicated chain of events, cause great physical upheavals on Earth. All that really happened, of course, was a rare and very interesting concentration of all nine planets into the same quadrant of the sky as viewed from the Sun. During this month's alignment, the four major asteroids — Ceres, Vesta, Pallas, and Juno — do not participate. Furthermore, Earth — though only Earth — lies well outside the heliocentric quadrant containing the other eight planets.

But on the other hand, the span of sky into which the planets are compressed — about 70° — is much smaller than that of the 1982 grouping. In contrast, the planetary alignment of February 1982 never covered less than 104° of sky. And, as an added attraction this time, the grouping results in several remarkable two- and three-planet conjunctions.

Viewing conditions improve during the month as **Mercury** pulls out from inferior conjunction with the Sun, reaching greatest elongation (24.3°) in the morning sky on January 22. And right about this time begins the excellent series of conjunctions.

On any of these January nights, the first planets to rise are **Pluto** (which requires at least an 8-inch telescope to see) and **Mars**, farther to the south. The Red Planet lies to the east of Spica this month and starts out fainter than that star, but the planet brightens by half a magnitude during January. Mars will surpass the brilliance of Spica by the third week of the month, when it reaches 0.9 magnitude.



Monitor Mars as it brightens to rival Spica's glow. As January ends, Mars lies over 90° west of the Sun. The Red Planet is just a little more than three months from a moderately close opposition.

Saturn is the next planet working its way eastward into the pre-dawn sky. Its slow progress carries it just a few degrees north of Alpha (α) Librae this month, but it will be overtaken by speedy Mars in mid-February. This golden planet shines at magnitude 0.7, which by then should be very close to the brightness of Mars.

Sixth-magnitude **Uranus** is only 38° from the Sun when Venus passes less than 2° north of it on the 10th. It will be much farther from the Sun in the last week of the month. In the last few days of the month, when the Moon's light doesn't interfere, try sighting Uranus without optical aid. This feat requires very dark skies.

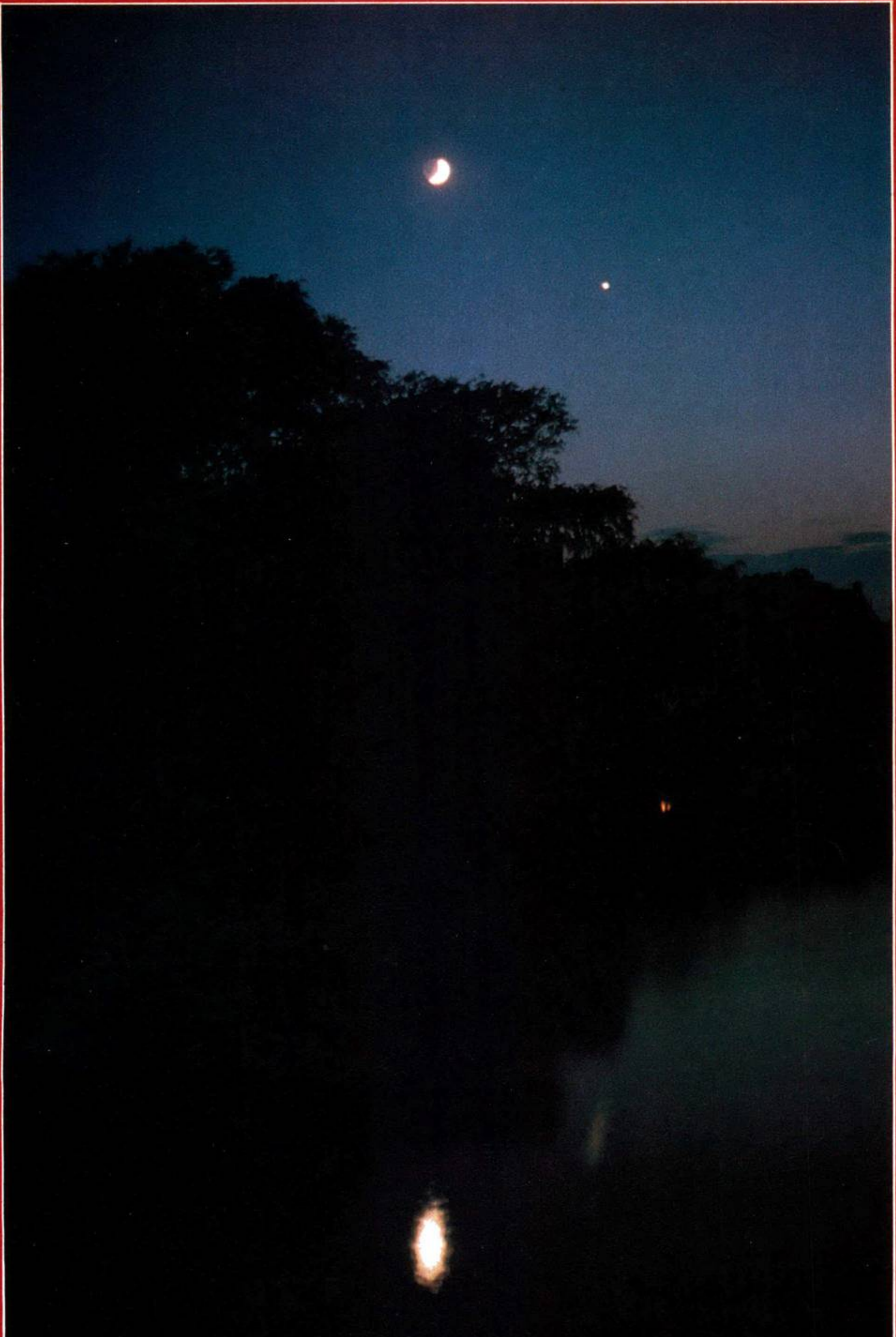
Venus begins to backtrack toward the Sun and diminishes to -3.4 magnitude in January. This will be a poor year for the planet. Still, Venus remains the dominant planet of the heavens after it rises, about two hours before the Sun comes up. Meanwhile **Jupiter** and **Neptune** emerge from morning twilight during the month, heading toward a meeting with Venus.

Before the three meet, Jupiter first overtakes Neptune. Jupiter passes the seventh-magnitude planet for the first observable conjunction in 13 years between the mornings of the 19th and 20th (for North America). This is the last observable conjunction between the two until 2009. But at least it's a close one — Jupiter passes just 52 arcminutes south of Neptune. Of course, faint Neptune is really five times farther off than Jupiter.

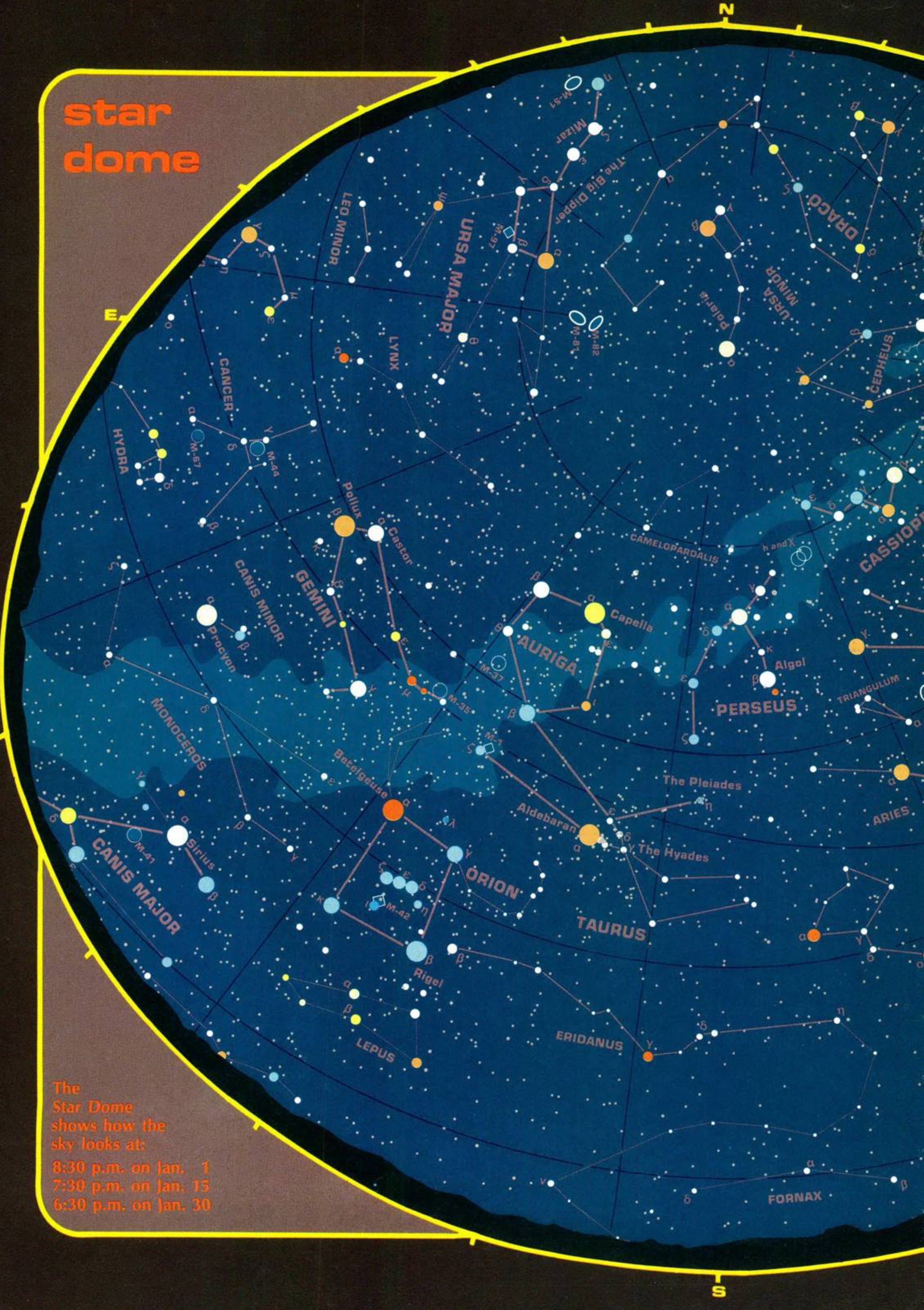
You'll need a telescope to spot Neptune, especially on these mornings when it is still only 29° from the Sun. If you own a telescope, have it handy for yet another reason: On the morning of the 20th, Jupiter passes just 6½ arcminutes south of the center of M-20 — right across the Trifid Nebula! And little more than a degree to the south of them lies the bigger, brighter Lagoon Nebula (M-8). These planets move so slowly (especially Neptune) that they will remain near each other and the nebulosities for several weeks. On the 21st, Venus is already just 6° away and closing fast. Both naked-eye observers and those with telescopes will be in for a treat the following week.

For information on viewing the Moon, planets, and deep-sky objects with telescopes, see **The Backyard Astronomer**.

About 11½ hours after their conjunction on June 14, 1983, P. van Graafeiland of the Netherlands caught the young Moon and Venus *shortly after sunset.* He used 100-speed film, a 28mm lens set at f/1.7, and an exposure of 10 seconds.

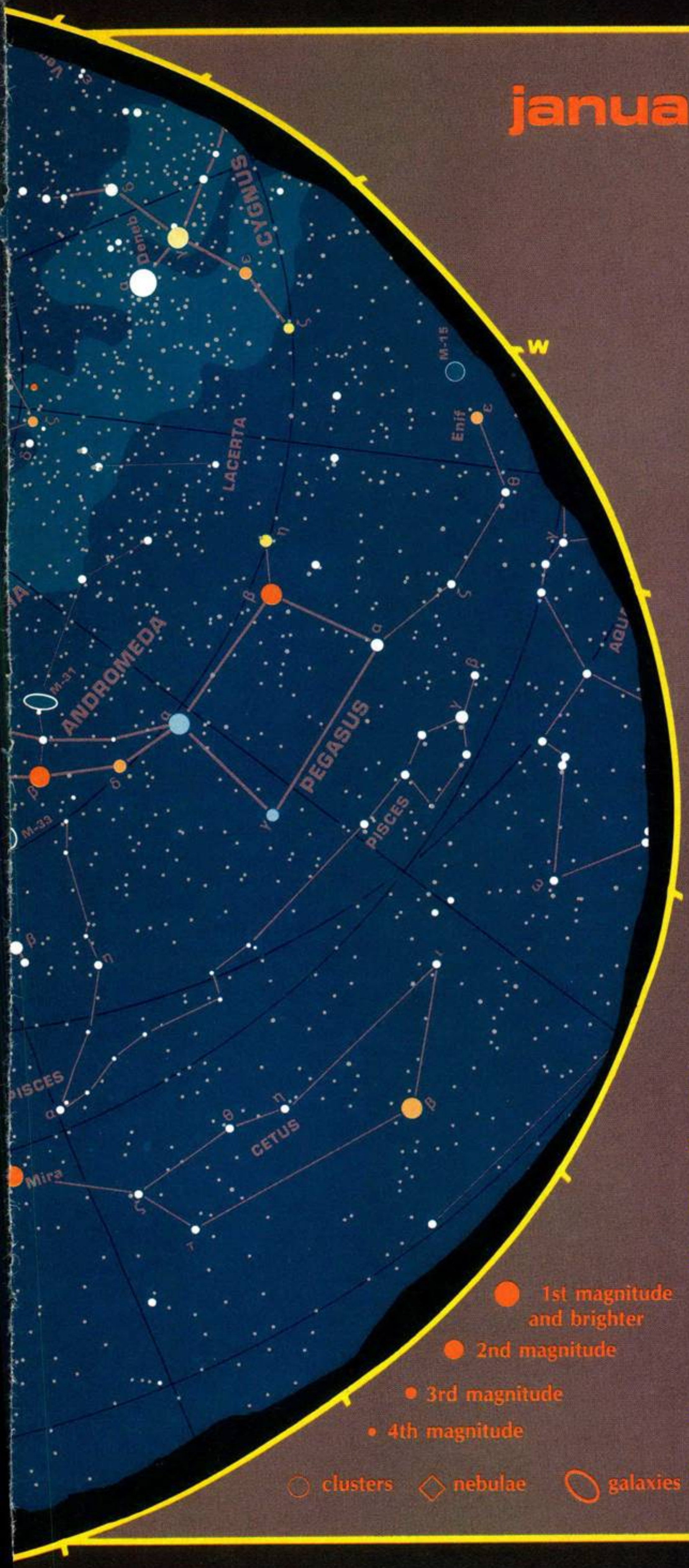


star dome


N
E
S
URSA MAJOR
The Big Dipper
Mizar
M-51
M-97
M-81
M-82
LEO MINOR
LYNX
CANCER
M-44
M-67
HYDRA
DRACO
URSA MINOR
Polaris
CEPHEUS
CASSIOPEIA
CAMELOPARDALIS
h and χ
Pollux
Castor
GEMINI
CANIS MINOR
Procyon
AURIGA
Capella
M-37
M-35
M-1
PERSEUS
Algol
TRIANGULUM
ARIES
MONOCEROS
Betelgeuse
The Pleiades
Aldebaran
The Hyades
TAURUS
ORION
M-42
Rigel
CANIS MAJOR
Sirius
M-41
LEPUS
ERIDANUS
FORNAX

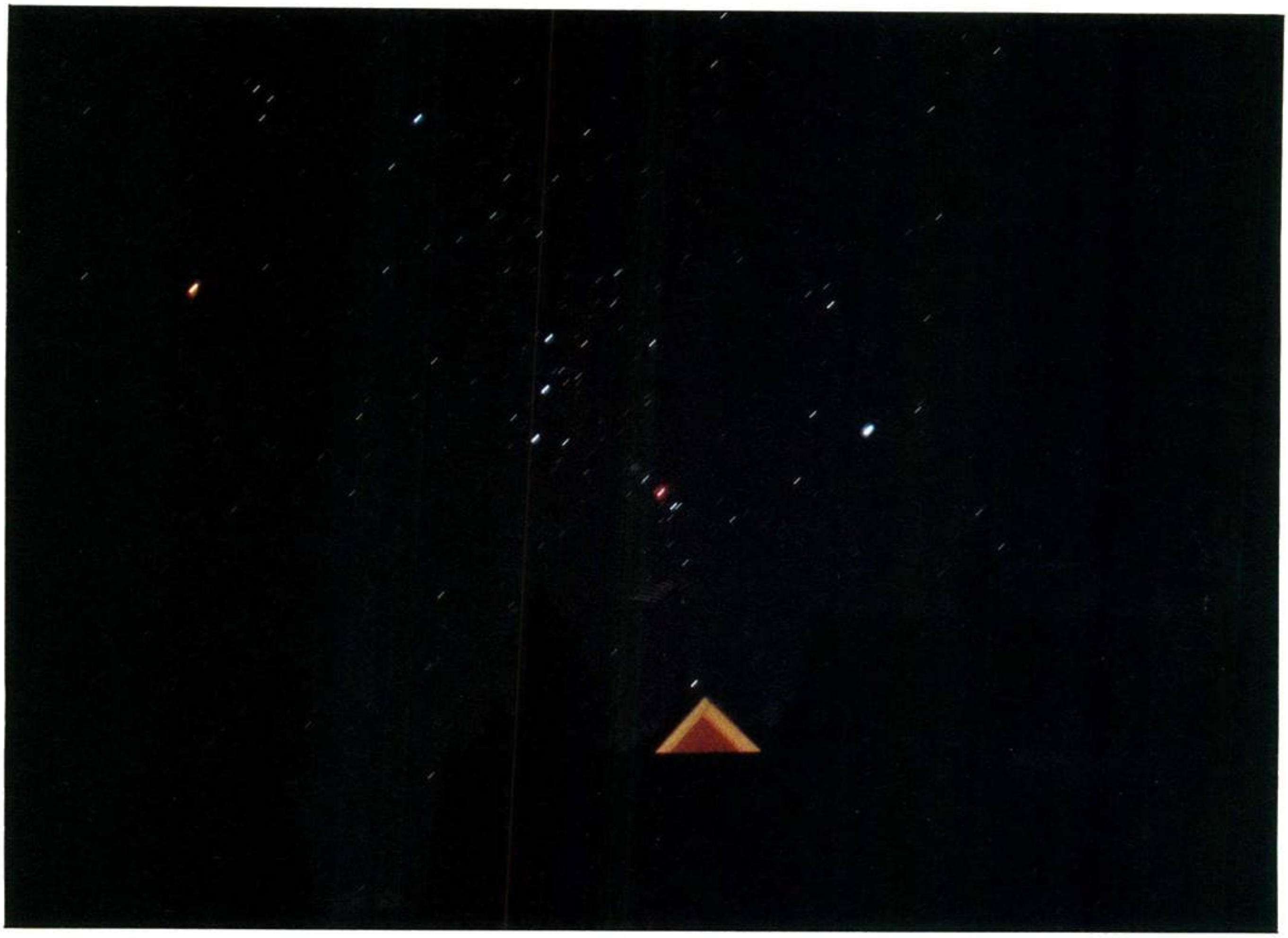
The
Star Dome
shows how the
sky looks at:

8:30 p.m. on Jan. 1
7:30 p.m. on Jan. 15
6:30 p.m. on Jan. 30


W
M-15
Deneb
CYGNUS
LACERTA
Enif
ANDROMEDA
M-31
PEGASUS
AQU
PISCES
M-33
PISCES
CETUS
Mira
1st magnitude and brighter
2nd magnitude
3rd magnitude
4th magnitude
clusters
nebulae
galaxies

january sky almanac

3rd	The Moon is New at 12:16 a.m. EST. Also, at 5 p.m. EST, Earth is at perihelion: 91.32 million miles.
4th	The Quadrantid meteor shower reaches its peak activity in today's predawn hours (see Gazer's Gazette, page 75).
5th	In the next few days, start looking for Mercury in the southeastern sky during the hour before sunrise.
7th	The Moon is at apogee at 3:08 p.m. EST: 252,036 miles.
10th	Venus will pass 1° 50′ of arc north of Uranus at 7:37 a.m. EST. (See text for descriptions of this and other conjunctions this month.)
11th	First Quarter Moon occurs at 4:48 a.m. EST.
17th	Mercury is at highest elevation in the southeastern sky this morning. Look for a reddish dot of light about 8° high, 45 minutes before sunrise.
18th	Full Moon is at 9:05 a.m. EST.
19th	Jupiter will pass 52′ of arc south of Neptune at 12:23 p.m. EST. Also, the Moon is at perigee at 4:38 p.m. EST: 223,419 miles.
20th	Jupiter is in conjunction with M-20, the Trifid Nebula.
22nd	Mercury is at greatest western elongation (24°) today.
24th	Last Quarter Moon occurs at 11:48 p.m. EST.
25th	Neptune is in conjunction with the Trifid Nebula. Later, Venus passes 47′ of arc north of the Trifid Nebula at 6:15 p.m. EST and 2′ of arc north of Neptune at 6:21 p.m. EST.
26th	Venus passes 51′ of arc north of Jupiter at 8:44 p.m. EST.
30th	The Moon will lie 3° south of Mercury in the morning sky.



Orion contains many bright bluish stars, orange-colored Betelgeuse, and the Great Nebula (M-42), a region of glowing gas that appears as a pink smudge in this photo. Peter Foppes used 200-speed film, a 50mm lens set at f/1.4, and a 30-second exposure to catch Orion rising.

First, on the evening of January 25 (for North America) Venus has a conjunction far closer than its December meeting with Saturn. At about 23 hours UT on that date, Venus is 1′31″ north of Neptune — the closest conjunction of the planets since 1955. (The only conjunction closer than the one this month was in 1982, when Venus passed 1′30″ from Uranus. Unfortunately, both planets were unobservable.)

But this month's great conjunction doesn't just involve Venus and Neptune, for Jupiter still lurks nearby, overwhelming the Trifid. For a day or two around the 25th, Venus, Jupiter, faint Neptune, and M-20 will be contained in a circle no more than about 2° across!

That's fascinating to know even if you don't own a telescope, but the North American naked-eye observer has a great opportunity on the mornings of the 26th and 27th when Venus moves past Jupiter. At best, Venus is just 51 arcminutes north of magnitude -1.4 Jupiter — the closest observable conjunction of these two planets until 1987.

Last of the Sun's planetary retinue is Mercury, which decreases in elongation after the 22nd. All five of the classical planets should be visible at one glance during the last 10 days of January, but there is one additional problem about observing them during this period — the Moon. Luckily, the Moon is an added delight rather than a problem in the very last days of January. It shrinks to a thin crescent and passes near a planet on almost every successive morning.

It is also fortunate that Mercury's elongation decreases slowly, so that it will actually be easier to see all the planets in early February — though by then Mars and Pluto will have moved on, widening the narrow span of planets.

the starry sky

The "heartland" of winter's bright stars is, of course, **Orion**, the Hunter. In number of bright stars, his radiance is unmatched by any other constellation. Orion's unmistakable belt of three stars — **Alnilam**, **Alnitak**, and **Mintaka** — lies near the celestial equator, so that at least part of the constellation is visible from everywhere on Earth. Brighter than the belt stars, however, are Orion's two famous giants — red Betelgeuse and blue Rigel.

Although usually an object of about magnitude 0.7, **Betelgeuse** is a variable star capable of large and rapid fluctuations in brightness. Its color is not true red, of course, but rather a deep orange or orange-gold. In beautiful contrast glows **Rigel**, distinctly brighter than Betelgeuse, and the most luminous of Orion's many blue giants. Also in Orion, visible around the middle star in his sword (just below the belt) lies perhaps the most beautiful of all deep-sky objects in a telescope — the Great Nebula (M-42). On a fine night, it even looks good in a pair of binoculars. We'll have more to say about the nebula and its relation to the stars of Orion next month.

To the upper right (northwest) of Orion is **Taurus**, the Bull. His face is formed by the Hyades star cluster and another giant star — **Aldebaran**, usually slightly yellower and a bit fainter than Betelgeuse. And don't forget the delicate **Pleiades** cluster (M-45) in the Bull's shoulder — one of the finest of all naked-eye sights in the heavens. But you will need a telescope to find another Taurus object, one that has been the subject of a great deal of astronomical research: the **Crab Nebula** (M-1). It lies near the naked-eye star Zeta (ζ) Tauri, one of the points of the Bull's horns. Imagine what it must have looked like in July of 1054, when a once-stable star exploded as a supernova. On that summer morning nearly a thousand years ago, the tip of one of the Bull's horns gleamed with a star brighter than Venus.

Auriga, the Charioteer, rides above Taurus. It's brightest star, **Capella**, just outshines Rigel, and three stars known as "the Kids" lie nearby. Farther east, **Gemini**, the Twins, dangle their feet in the Milky Way near the Bull's horns, their heads marked by the prominent stellar pair, **Castor** and **Pollux**. They culminate in mid-evening later this winter, as does yet another first-magnitude star due south from Pollux — **Procyon**. The name of this star, the brightest in **Canis Minor**, the Little Dog, means "before the dog" — because at many latitudes Procyon rises just before the Dog Star.

The Dog Star is, of course, **Sirius**. The most brilliant star in the sky, twinkling Sirius is lovelier than the few planets able to outshine it. One of the factors that help make Sirius the brightest star is its proximity: it's little more than eight light-years distant, the nearest of all prominent stars visible north of the tropics.

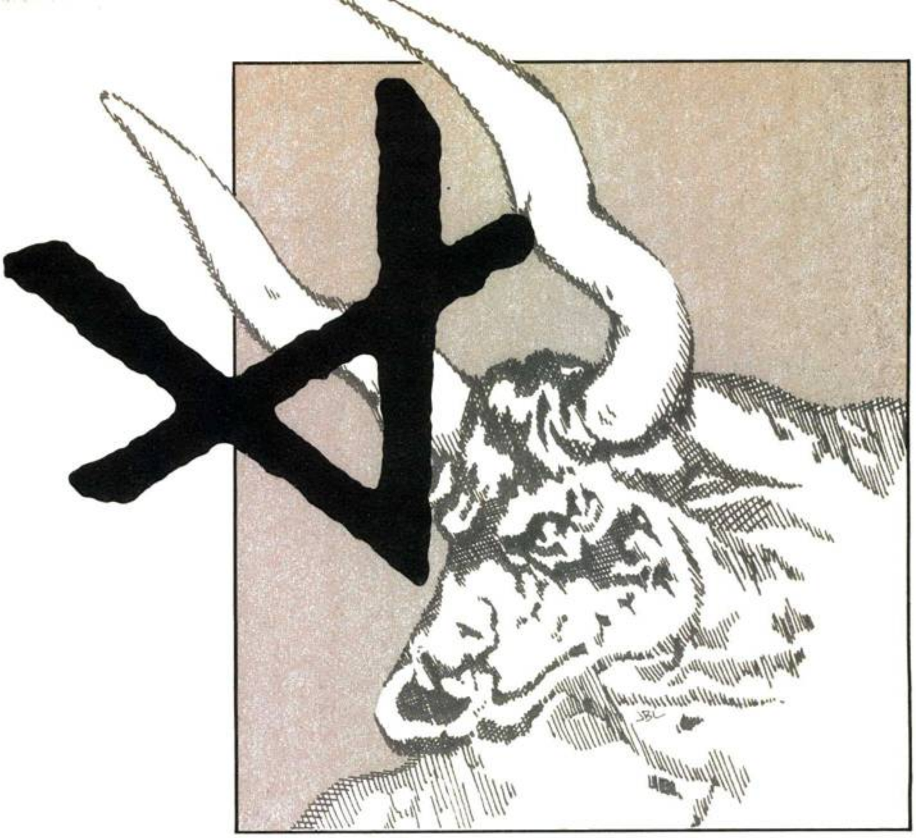
Next month both Sirius and Procyon are higher in mid-evening, but January is the last month you can see them rising in a dark sky. Go out as evening twilight fades, and make sure you have an unobstructed view to the east. How low can you detect these two stars with unaided eyes or binoculars? Incidentally, extending the line of Orion's belt downward takes you to the approximate point where Sirius rises.

Sirius shines in the bright constellation **Canis Major**, the Great Dog, the southeast tip of a vast island of bright stars. But what underlying physical structure produces this region of bright stars?

When you look toward Orion, you are staring into the richest part of the spiral arm that carries the solar system. The Milky Way glows brighter in summer because we see the Galaxy's far-off interior arms, which lie between Earth and the galactic center. But many of the most luminous stars within a few thousand light-years of the solar system lie in the direction of Orion — in fact, we call our own spiral arm the Orion Arm.

But there are more bright stars west of the Milky Way band (that is, south of the galactic equator) in the winter sky. This feature is called **Gould's Belt**: most of the bright stars of the sky lie roughly along a circle inclined about 18° to the galactic equator, the mid-line of the Milky Way band. Gould's Belt crosses the galactic equator in Cassiopeia and again near Alpha (α) and Beta (β) Centauri, but extends rather far from the equator in both Orion and Scorpius.

What feature of galactic structure does Gould's Belt represent? It seems to be a kind of spur inclined slightly out of the Galaxy's plane. It is only a relatively local feature, a part of the Orion Arm, and though it will last for many millions of years, it is just a transitory feature in the life of the Galaxy.



skylore

Last month we dealt with the myth of Europa and its connection with Taurus the Bull. There is such a wealth of lore concerning bulls in general, and Taurus in particular, that we can only deal with a few special topics here this time. For the present, let's see how Taurus relates to the first letter of the alphabet and the origin of unicorns.

Taurus may be a very ancient constellation because of its importance in the earliest period of recorded history: from about 4000 to 1700 B.C. Taurus contained the vernal equinox, the point where the Sun crosses the celestial equator in its northward push toward summer. (The equinox has since moved on, driven by precession, through Aries and into Pisces.) All early cultures started their calendar at the vernal equinox. So Taurus was not only the first constellation in the order of the zodiac, but also the beginner of the year.

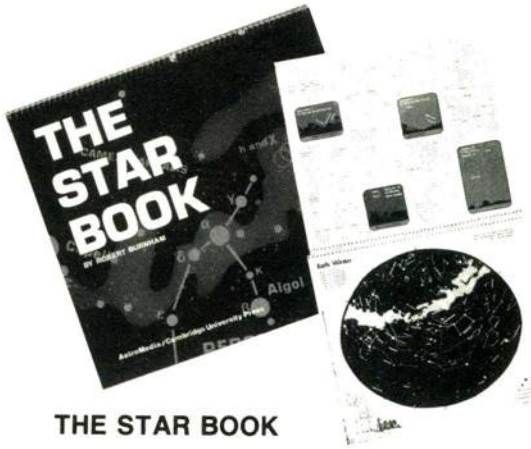
But how does this relate Taurus to the alphabet? The celestial bull of the early Egyptians was apparently not the one we recognize. The Mesopotamian Bull of Light, or Gut-an-na (Heavenly Bull) did, however, represent today's Taurus. Yet neither of these cultures gave us our alphabet. Our letters derive from the Phoenicians, from whom many Semitic peoples — including the Hebrews — adopted their alphabets. The Hebrew word for the first letter is *aleph*, which means "ox." Some philologists believe that our letter A started off upside-down — ∀ — a rather good likeness to the head of an ox or bull.

Could the letter A have been chosen to lead the letters of the alphabet because it represented the animal that led the order of the zodiac and started the year? Quite possibly — so Taurus may have given us the first letter of our alphabet.

Taurus also may have some interesting associations with other constellations. Least satisfying is a possible connection with adjacent Perseus and Andromeda. This only works if you consider Taurus to be Zeus's lover Io in cow form. (Both Perseus and Andromeda were descendants of Io.) But Taurus is usually said to represent Zeus himself in the guise of a bull. Somewhat more interesting is the observation that every horned constellation in the sky (except Capricornus, the Seagoat) lies near Taurus. Aries, Camelopardalis, Monoceros, even the goats held by Auriga — all are placed in the vicinity of Taurus.

The constellation Monoceros is a rather modern invention, but unicorns are not — according to one suggestion, unicorns were derived from Taurus. In ancient Mesopotamia, there were numerous portrayals of the bull of spring (Taurus) and the lion of summer (Leo) facing each other (as the modern constellations still do). The two were shown in profile, so only one of the bull's horns could be discerned. Down into modern times, there has been a tradition of portraying the lion and the unicorn together, but the reason for their association is, to the best of my knowledge, unexplained. So perhaps we also owe the mythical unicorn to mighty Taurus the Bull. Next month, we'll explore the subject of unicorns and the constellation Monoceros.

ASTRONOMY
Products for Observers


THE STAR BOOK
BY ROBERT BURNHAM
Algol
AstroMedia/Cambridge University Press

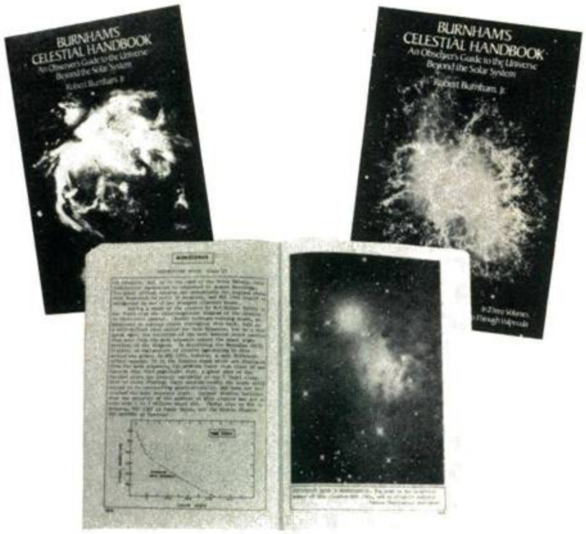
THE STAR BOOK

Learn the constellations with **THE STAR BOOK**, from AstroMedia. 8 charts cover all seasons, providing enough overlap for easy identification of prominent star patterns. Each map is accompanied by a description of the stars, the constellations and their lore and legends written by ASTRONOMY's Robert Burnham.

- **all northern constellations shown**
- **easy to use at night**
- **10'' x 11¼''**
- **folds back for your convenience**
- **printed in two colors on thick cardstock**
- **coated with a durable water-resistant varnish**
- **heavy-duty wire binding**
- **will give years and years of service**

THE STAR BOOK......................$6.95

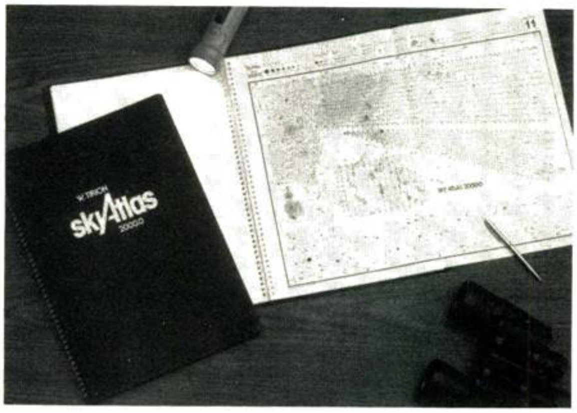
Foreign orders add $1.50


BURNHAM'S CELESTIAL HANDBOOK
An Observer's Guide to the Universe Beyond the Solar System
Robert Burnham, Jr.
BURNHAM'S CELESTIAL HANDBOOK
An Observer's Guide to the Universe Beyond the Solar System
Robert Burnham, Jr.

BURNHAM'S CELESTIAL HANDBOOK: Burnham. The great modern classic about deep-sky objects; each constellation has an introductory section with descriptions of double and multiple stars, variable stars, star clusters, nebulae and galaxies. Includes photographs, tables, graphs and finder charts — a must for your library. 3 volumes, 2138 pages in all, paperback.

Vol. 1 — Andromeda through Cetus
Vol. 2 — Chamaeleon through Orion
Vol. 3 — Pavo through Vulpecula

Vols. 1 and 2, $10.50 each; Vol. 3, $12.50


Sky Atlas 2000.0

SKY ATLAS 2000.0

Join the ranks of knowledgeable amateur astronomers with **Sky Atlas 2000.0.** Find your way to galaxies, star clusters, and nebulae.

- 26 wire-bound charts each 12½'' x 17½''
- 43,000 stars — to the 8th magnitude
- 2,500 color-coded deep-sky objects

. . . and more.

SKY ATLAS 2000.0...................$34.95

Foreign orders add $2.00

ALSO AVAILABLE: SKY CATALOGUE 2000.0. 632 pages of information on over 45,000 stars — including positions, spectral type, and distance. Paperback, **$29.95.**

Planisphere
Planisphere
Planisphere
Planisphere

PHILIPS' PLANISPHERES

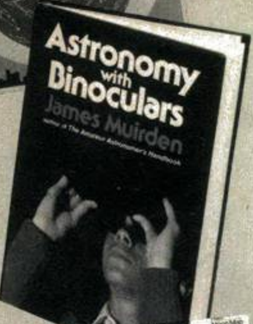
A **Philips' Planisphere** shows you the principal stars and constellations visible for every hour in the year. Just rotate the 2 plastic discs until the hour and date coincide. You can see what time Leo rises in mid-January, when the Pleiades set in May — "what's up" at any time, on any date.

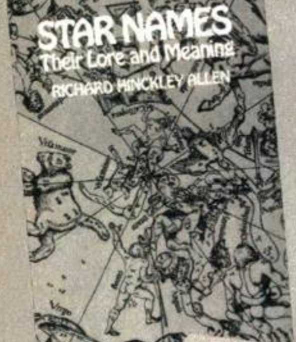
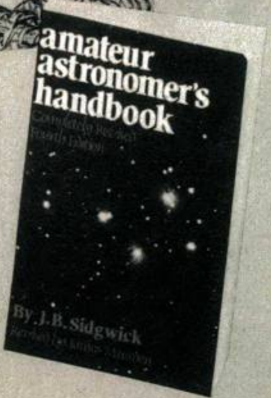
Lightweight and made of waterproof plastic, a planisphere is portable and durable enough to be taken anywhere — back-packing, sailing or your own backyard.

The 10'' diameter size is available in 3 latitudes: 52°, 42° and 32°. The 5'' pocket-size model is available in 42° and 32° ranges only. PLEASE SPECIFY LATITUDE.

10'' PHILIPS' PLANISPHERE 52°, 42° or 32° $8.95
5'' PHILIPS' PLANISPHERE 42° or 32° ...$5.95

NEW! PHILIPS' DELUXE PLANISPHERE. For the travelling observer — 3 planispheres in one! Has the same high-quality features found in the standard models, PLUS *interchangeable overlay discs for accuracy almost anywhere* in the Northern Hemisphere. Includes snap-on overlays for 32°, 42° and 52° and comes in an album-style pouch. **$14.95**



SEASONAL STAR CHARTS. Guide to the heavens with 8 star maps and accompanying lists of objects in each constellation; has Star Finder planisphere on cover. 23 pages, plasticized paper, ring-bound to lie flat. **$8.50**

THE MESSIER ALBUM: Mallas & Kreimer. An observer's guidebook to the whole Messier catalog — a finderchart, visual sketch and description, and a photo on each. 248 pages, hardcover. **$14.95**

ASTRONOMY WITH BINOCULARS: Muirden. The classic guide to sky-watching with the simplest equipment. Includes how to buy a good pair of binoculars and observing projects. 156 pages, hardcover. **$13.95**

OBSERVING EARTH SATELLITES: King-Hele. From the first Sputnik launch in 1957 to the Shuttle and Salyut space stations, the number of satellites orbiting the Earth has grown to over 5,000. Many are visible from the ground, and this is a practical guide for anyone who wants to follow them — using naked eyesight or binoculars. 184 pages, hardcover. **$16.95**

MOON MAP: Helps you identify the Moon's anonymous jumble of craters, hills and flat expanses you can see with your telescope. It includes an index, as well as a description of the Moon's original and surface features. Shipped folded in a protective cardboard cover, the Moon Map can be mounted for display. 20" x 29" **$3.95**

ASTRONOMICAL TABLES OF THE SUN, MOON AND PLANETS: Meeus. With over 100 tables and graphs, details solar and lunar eclipses and lunar phases between 1951 and 2050, tabulates the occultations of planets and 1st magnitude stars between 1980 and 2000, and lists all planetary conjunctions between 1976 and 2025. Approx. 400 pages, paperback. **$20.50**

SKYGUIDE: Chartrand. Subtitled "a field guide for amateur astronomers," the chapters include basic astronomy, telescopes and mountings — with detailed charts of each constellation, as well as color plates describing planets, stars, asteroids, eclipses, and more. 280 pages.
Hardcover $9.95 **Paperback $6.95**

365 STARRY NIGHTS: Raymo. Takes you through the year one night at a time and introduces the beginning stargazer to the wonders of the sky in an easy, yet very thorough way. Illustrated with clever and informative pen and ink drawings. 225 pages, paperback. **$13.50**

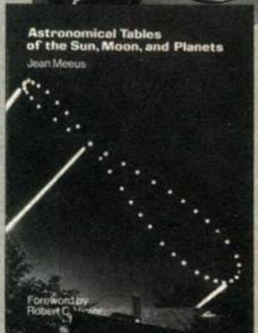
STAR NAMES: THEIR LORE AND MEANING: Allen. The classic source for the legends behind star names and constellations as well as other celestial folklore. 563 pages, paperback. **$7.50**

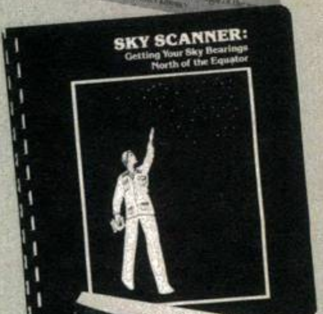
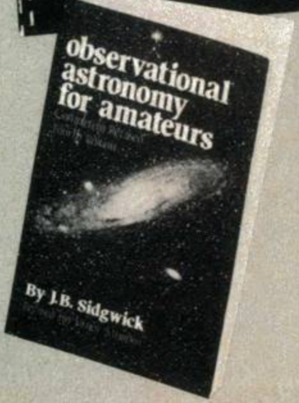
SKY SCANNER: Nowell. Compact star charts showing the brightest constellations; ideal for learning the sky. 12 pages, heavy paper, lies flat. **$4.95**

AMATEUR ASTRONOMER'S HANDBOOK, 4th ed.: Sidgwick. Tips on mountings and drives, eyepieces, mirror and lens testing — as well as data on human vision, the Earth's atmosphere, etc. 568 pages, paperback. **$8.50**

OBSERVATIONAL ASTRONOMY FOR AMATEURS, 4th ed.: Sidgwick. A collection of facts on observing techniques covering the Sun, Moon and all the planets, as well as aurorae, meteors, zodiacal light and double stars. 348 pages, paperback. **$6.50**

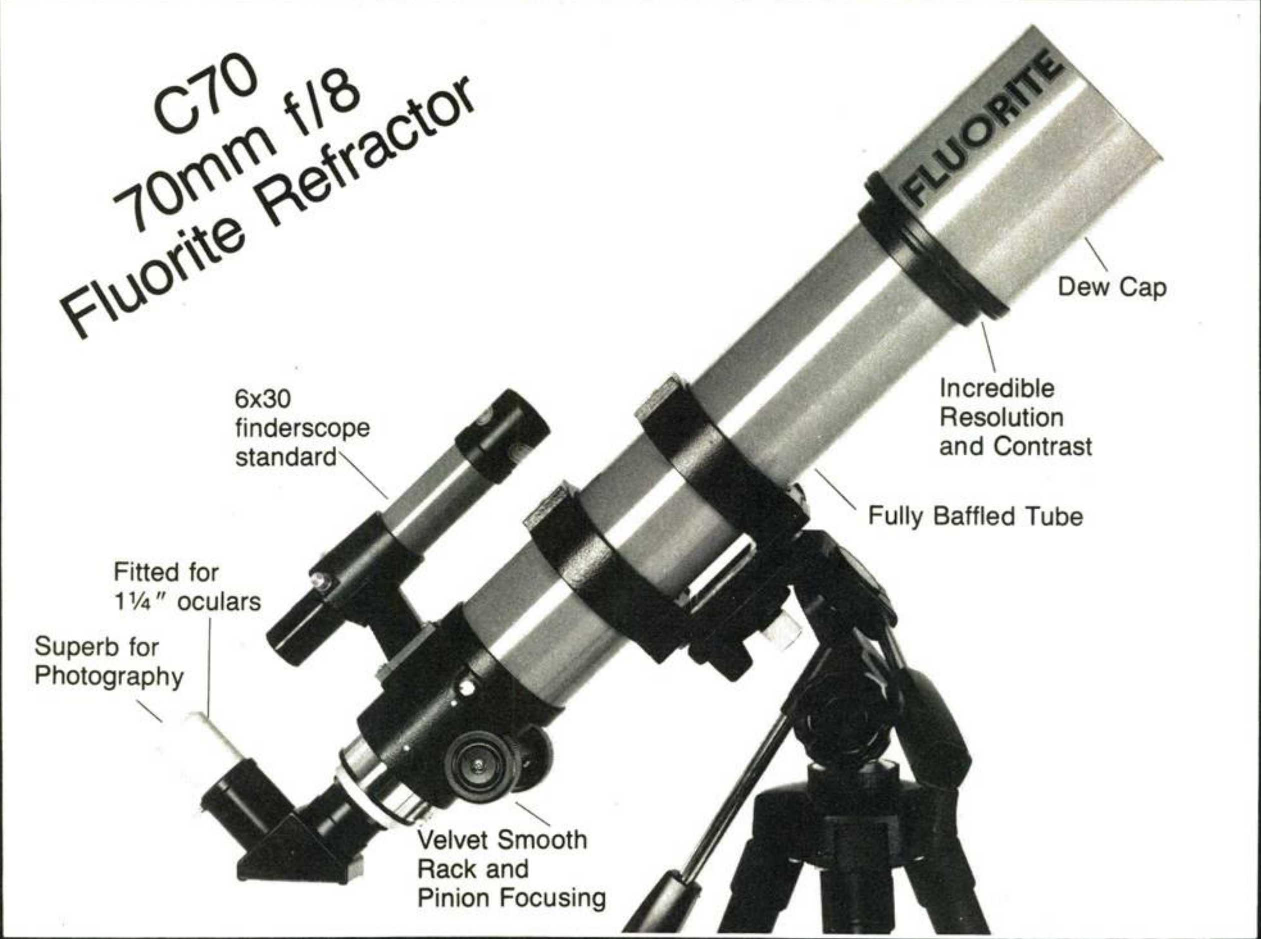
To order any item on these 2 pages, use the AstroMedia order form bound into this magazine, or send to AstroMedia Order Dept., P.O. Box 92788, Milwaukee, WI 53202.



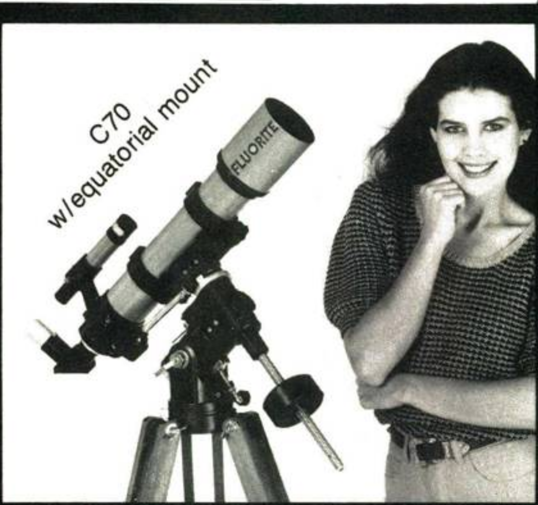
FLUORITE REFRACTORS

NOW AT YOUR CELESTRON DEALER!


C70
70mm f/8
Fluorite Refractor
FLUORITE
Dew Cap
Incredible Resolution and Contrast
Fully Baffled Tube
6x30 finderscope standard
Fitted for 1¼″ oculars
Superb for Photography
Velvet Smooth Rack and Pinion Focusing

WHY A FLUORITE TELESCOPE?

Celestron, the world's largest manufacturer/supplier of quality telescopes, is proud to unveil a new telescope - the C70 *Fluorite* Refractor Telescope. Refractors have traditionally been frowned upon because of "chromatic aberration". Modern refractors have achromatic lenses to control this aberration, but, for "perfect" images you need either more lens elements (usually at much higher cost) or a material called *Fluorite* which until now has only been available in extremely expensive telescopes. The Celestron Fluorite Refractors have a lens element from Fluorite that lets Celestron offer you a telescope with exceptional contrast and resolving power at a reasonable price. The Celestron Fluorite Refractors aren't for everybody, they're for people who want a perfect image. To look through one, see your local Celestron dealer. Other sizes (55mm, 80mm, 90mm diameter) available on special order.


C70
w/equatorial mount
FLUORITE

Questions? Call Celestron's Telescope Information Service Toll Free Continental USA Only

1-800-421-1526

Please call or write for dealer locations, catalogs or technical specifications
CELESTRON INTERNATIONAL - P.O. Box 3578-B9 - 2835 Columbia Street - Torrance, CA 90503 (213) 328-9560

PRECISION OPTICS FROM CELESTRON®

clocks and calendars in astronomy

equipment atlas

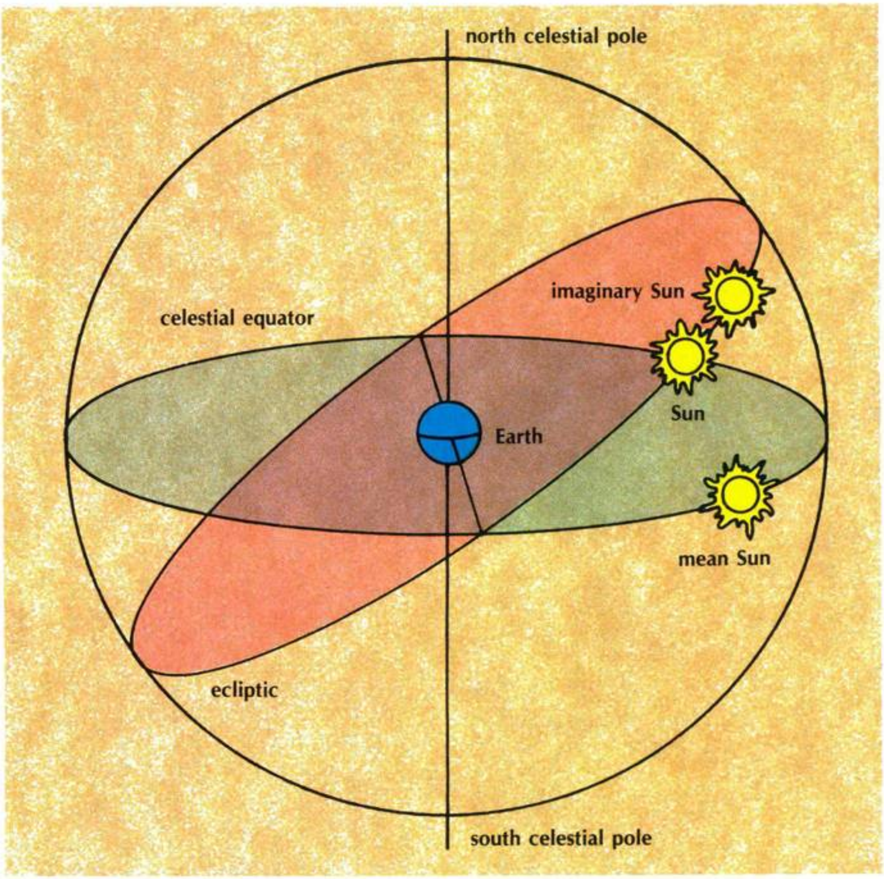
by

Sethanne Howard

We humans care about time. All around, natural rhythms alert us to its passage: The Sun rises and sets each day; the Moon completes an orbit each month; the tilt of our planet's axis creates seasons to mark the years. But of all the natural cycles around us, the Earth's daily rotation remains our primary timekeeper. Clocks are simply interpolating devices that measure the elapsed time between two consecutive overhead passes of the Sun — a *solar day*. Such a clock can be as simple as a stick in the ground that casts a shadow during the day. The shadow will be shortest at only one point during the Sun's passage — at midday. We can define a full solar day as the interval of time between two consecutive "shortest shadows." This method was used quite early in our history — it's pictured on Egyptian pyramid texts dating back as far as 1450 B.C.

The solar day defines *apparent solar time*, which is equivalent to the Sun's local hour angle — its distance east or west from your meridian. But solar time does not flow uniformly. The Sun's local hour angle changes throughout a year because of the eccentricity of our planet's orbit around it. The Sun's apparent location at sunrise, midday, and sunset varies seasonally. Summer days are longer than winter days. This complication makes it difficult to use apparent solar time for the clocks that run businesses and governments. To make matters worse, the Earth's velocity along its orbit is not constant, so the Sun's rate of apparent motion through the sky also changes slightly throughout the year.

How, then, do we mark out civil time? Imagine our planet lying at the center of the celestial sphere. We can project Earth's rotational axis and equator onto the sphere, marking the celestial poles and the celestial equator, respectively (see accompanying diagram). As Earth moves in its orbit, the Sun appears to change its position with respect to the stars on the celestial sphere. The path along which the Sun appears to move is called the *ecliptic*. (Of course, the ecliptic actually represents the plane of Earth's orbit.)

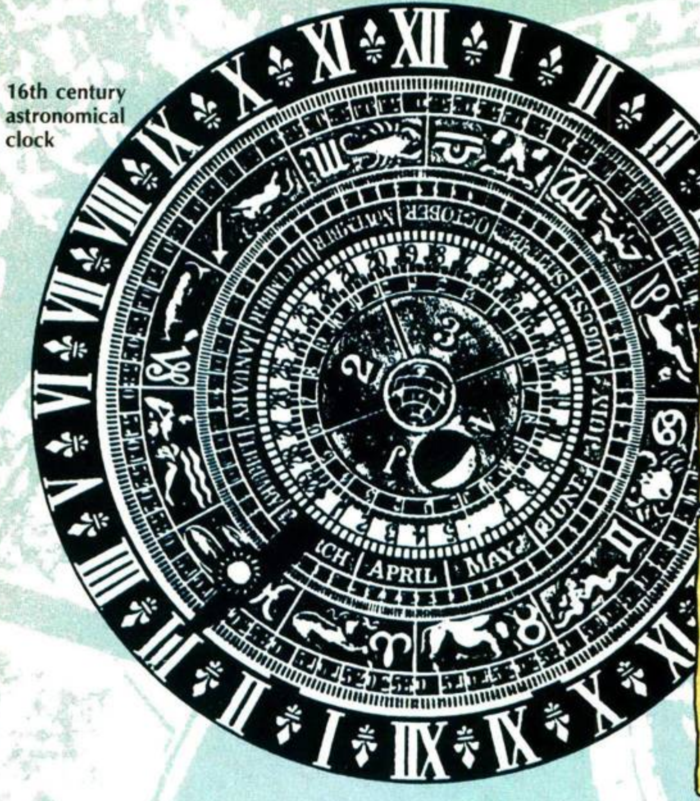


The Earth moves along in its orbit at some mean angular velocity, so the Sun moves across the celestial sphere at the same mean rate. The word "mean" is important, for the Sun's apparent motion is not uniform. This, of course, is the whole problem, for if the Sun traveled at a uniform rate we would have an unvarying natural clock.

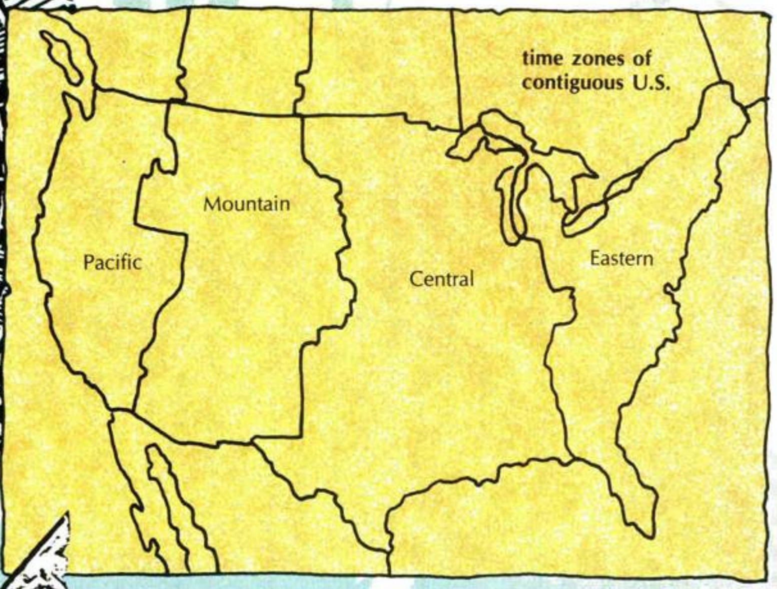
Astronomers get around this problem by defining an imaginary Sun. They start it moving at the real Sun's mean angular velocity across the sky. At the same time, they also start the true Sun from the same point. After a certain amount of time, there is a finite angular distance between the real Sun, which moved at a non-uniform speed, and the imaginary Sun, which constantly trudged along at the real Sun's *mean* velocity.

But our fictitious Sun still travels along the ecliptic, and even though it moves at a constant rate, its hour angle won't change uniformly because we measure right ascension with respect to the celestial equator, not the ecliptic. So astronomers created another imaginary Sun, the *mean Sun*. The mean Sun travels along the celestial equator instead of the ecliptic, and does so at the mean angular velocity of the real Sun.

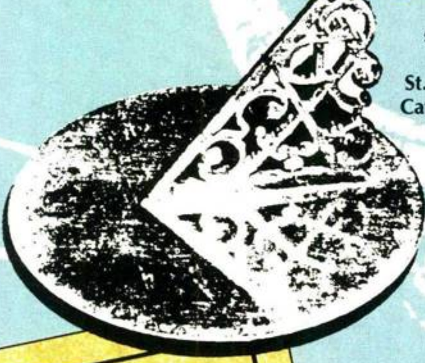
As we start the mean Sun moving along



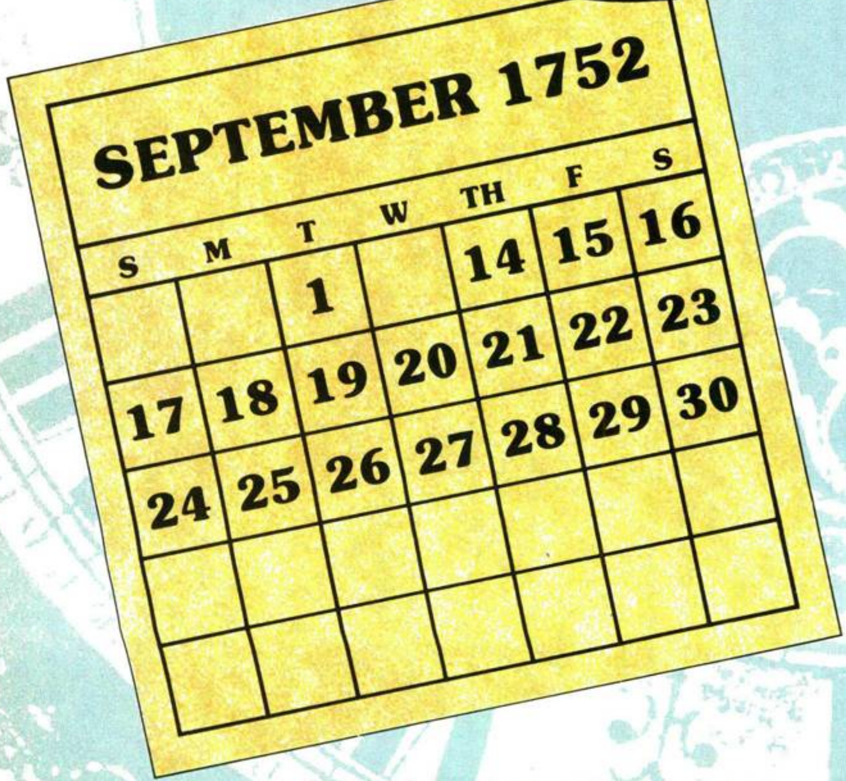
16th century astronomical clock


Mountain
Pacific
Central
Eastern

time zones of contiguous U.S.



sundial from St. Paul's Cathedral

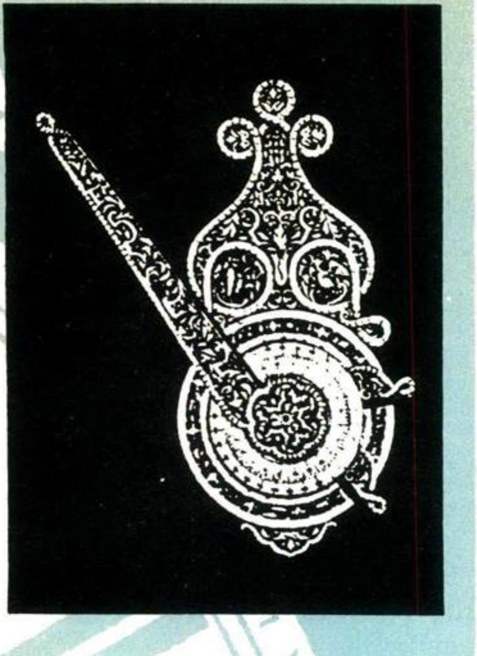


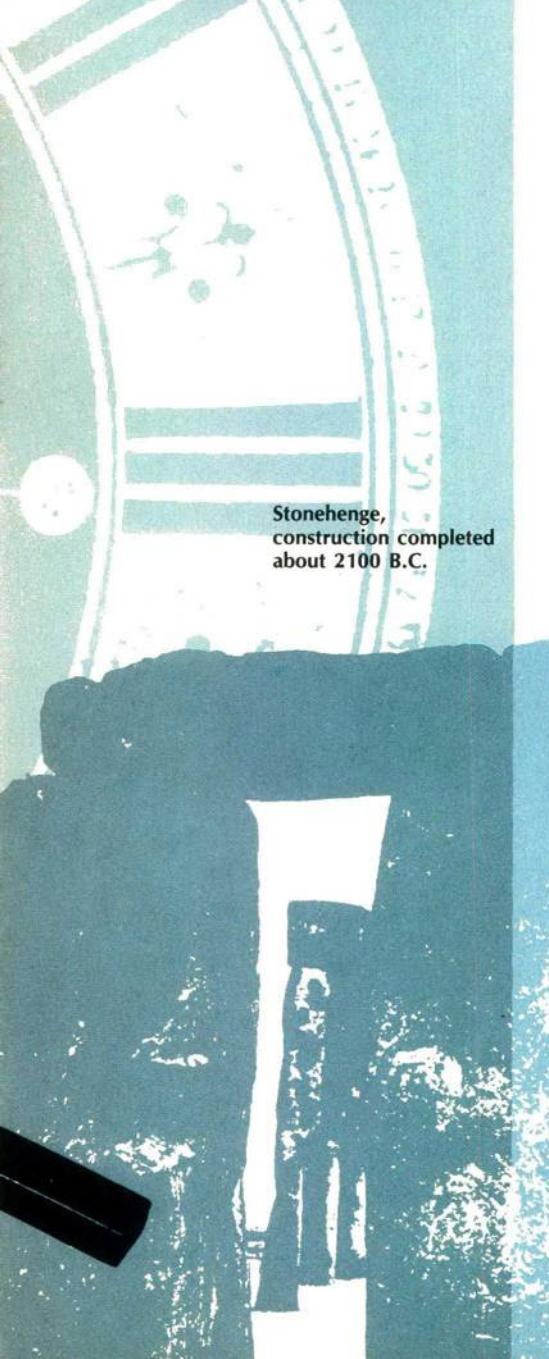
SEPTEMBER 1752

S	M	T	W	TH	F	S
		1		14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30

Egyptian shadow clock, 8th to 10th century B.C.

Background: Dial of astronomical clock used at Greenwich in mid-1700s.





Stonehenge, construction completed about 2100 B.C.

the equator at the mean velocity of the true Sun, its hour angle changes uniformly *and* is measured from the celestial equator. The mean Sun travels around the equator in the same time that the true Sun travels around the ecliptic. But while the mean Sun moves at a uniform rate, the motion of the true Sun varies in speed and direction. The difference in right ascension between the mean Sun and the true Sun is called the *Equation of Time*. Formally defined as the r.a. of the mean Sun minus the r.a. of the true Sun, the equation of time provides most of the correction needed to get sundial time to agree with your watch. The difference is sometimes negative, sometimes positive, and twice in the course of the year equals zero.

We can therefore define the *mean solar day* as the interval between two successive transits of the mean Sun across the meridian. The mean solar day gives us a uniform time, and we use it for civil reckoning. Of course, this mean time is not truly uniform because minor variations in the rate of Earth's rotation are unaccounted for. Over an 18-year cycle, the rotation rate varies by plus or minus one second — slow in the Northern Hemisphere's spring, fast in the autumn. In addition, the Earth's axis wobbles 30′ of arc about its mean direction; the rate of this wobble slows about $\frac{1}{1000}$ of a second each century.

In 1884, the nations of the world met in Washington, D.C., for the Washington Meridian Conference. They defined the "prime meridian" (0° longitude) to run through Greenwich, England. When the mean Sun is on the Greenwich meridian, the time, by definition, is Greenwich mean noon. Similarly, when the mean Sun crosses a local meridian, the time is local mean noon. *Greenwich mean astronomical time* is the hour angle of the mean Sun as seen from the prime meridian. Since 1925, however, Greenwich mean time (GMT) has been counted from midnight rather than from noon so as to match the conventions of ordinary timekeeping. Thus Greenwich mean time equals the hour angle of the mean Sun plus 12 hours.

Astronomers base their observations on *Universal Time* (UT), which also serves as the basis for civil timekeeping. UT is a measure of time that, within a very close approximation, conforms to the mean daily motion of the Sun. Like GMT, UT is the mean solar time on the Greenwich meridian reckoned in days of 24 mean solar hours beginning at midnight. A time system linked to the apparent daily motion of the stars would be more useful for astronomical purposes, since we can regard the stars as being fixed in position. UT fills the bill. Conventional relations tie it down to the meridian passage of the vernal equinox — the point where the Sun moves northward across the celestial equator — as seen from Greenwich.

Astronomers try to eliminate minor variations in UT, such as those introduced by seasonal variations or the wobble in Earth's rotation. But in the end, the unevenness and gradual deceleration of Earth's rotation add errors. Once the extremely uniform time scale of atomic clocks came into use, the minor variations inherent in Universal Time caused it to diverge from atomic time. In 1972, authorities introduced *Universal Coordinated Time* (UTC) to minimize this divergence; most broadcast time services use it today. Based on international atomic time, UTC is kept in step with the apparent daily motion of the stars by the insertion of precisely one second — a "leap second" — whenever necessary, usually at the end of June or December.

Naturally, the mean solar time for, say, Tucson, Arizona, cannot equal UT — after all, the Sun cannot be on the local meridian everywhere at the same time. The mean solar time for a locality other than Greenwich depends on its longitude; it will be less than UT (earlier in the day) if west of Greenwich, and greater (later) if east of Greenwich. Thus local mean time differs even over short distances due to this effect of longitude. Neighboring cities actually have a slightly different apparent time. Since the Earth rotates 360° every 24 hours, it takes four minutes to travel 1° of longitude, and four seconds to travel 1″ of arc of longitude. For example, if it's 12:00:00 local time at longitude 100°00′00″ West, then it's 11:56:00 at longitude 101°00′00″ West.

Until the mid-19th century, the town clock of each city used local mean solar time. When it took many hours to journey between cities, variations in local time did not matter much — travelers simply adjusted their watches by the clocks in each town. But by 1850, with the comparatively rapid transit introduced by railroads, time differences over great distances had become important. As a solution, Sandford Fleming of Canada and Charles F. Dowd of the United States proposed the system of time zones we now use. There are 33 standard time zones throughout the world (nine zones use a half hour increment), and the time is the same within each zone. The time in each zone is different from UT by the integral number of hours (or, in the nine odd zones, half hours) of longitude between Greenwich and the center of the time zone. The mean solar time within a time zone is called civil time.

Since UT measures the travel of the mean Sun, it is essentially a measure of the Earth's rotation. Since the rotation of our planet isn't precisely uniform, we need a kind of "dynamic time" whose rate is truly constant — *Ephemeris Time*, which is defined by the mean Sun's rate of motion at the instant the year 1900.00 began, and contains about 365.24 mean solar days. High-precision astronomy required an even more precise system, so this year Ephemeris Time was superseded

by *Terrestrial Dynamical Time*. Like UTC, this new system is tied to the uniform time scales of atomic clocks and takes relativistic effects into consideration.

Our major time-measuring unit is, of course, the period required for our planet to revolve around the Sun. We define the *tropical year* as the average interval between two successive passages of the mean Sun through the vernal equinox, or about 365.24 mean solar days. The *sidereal year*, on the other hand, is 365.25 mean solar days in length; it represents the time required for the mean Sun to return to the same position in the sky relative to the distant stars. These two years have slightly different lengths because precession inexorably pushes the vernal equinox along the celestial sphere.

Time was measured in days and months long before it was measured in years. But lunar calendars don't stay in step with the seasons very long — a real problem in an agricultural society! Eventually, a solar calendar had to come along. The development of agriculture helped early societies do this. They had to predict seasonal changes necessary for the planting and harvesting of crops. The seasons can be measured by the Sun's passage from solstice to solstice or equinox to equinox.

To a naked-eye observer, a solstice occurs when the Sun appears to rise at the same place on the horizon for several days in a row — late December and late June, for us. An equinox occurs in late March and late September, when day and night have equal lengths. The tropical year measured using these signposts is about 365.25 days long. Unfortunately, the Moon completes 12 lunation cycles in a period just 11 days short of a tropical year. Early civilizations went to great lengths to devise calendars to reconcile the lunar and solar cycles. One Babylonian king proclaimed: "The year is out of place. Have the next month recorded under the name of Ululu II. Payment of taxes at Babylon, instead of ending on the 25th of Tasritu, shall end on the 25th of Ululu II." The Babylonians started each new year on a New Moon. To make the seasons agree with this religious restriction, they utilized the observation that every 19 solar years a New Moon does coincide with the start of a solar year. By the 5th century B.C., they had come up with a workable lunisolar calendar. To the 12 months already in each of the 19 solar years, they scattered seven extra months throughout the period. The result: In every 19-year period, 12 years contained 12 months, while the 7 remaining years were each 13 months long. This lunisolar calendar is still used as the basis for the Jewish calendar, and can also be used for computing the date of Easter.

The basis for our calendar was invented by the Egyptians. For agricultural reasons, they began each year when the Nile flooded — around the time the star Sirius rose just before the Sun. They defined the year as twelve 30-day months plus five extra "holidays" tacked on at the end, giving a grand total of 365 days. Once started, their calendar lost one quarter of a day each year, which meant that Sirius would rise with the Sun a day later every four years.

The Egyptians stubbornly resisted correcting their calendar for the leftover quarter day. By the time of Julius Caesar, things were seriously out of step — in 46 B.C. the calendar trailed 80 days behind the Sun. Caesar revised the calendar that year with the advice of an Alexandrian astronomer. He declared that the year 46 B.C. now contained 445 days. The Romans promptly dubbed this the "year of confusion." Caesar also scattered the five tacked-on Egyptian holidays throughout the year by creating seven 31-day months, four 30-day months, and one 28-day month. (February was an unlucky month to the Romans.) He then added one extra day — a "leap day" — every four years to take care of the quarter day that the Egyptians didn't take into account.

The resulting Julian calendar became the standard for the Roman world, and in 325 A.D. the Nicean Council established it as the official Christian calendar. But despite Caesar's corrections, the true tropical year is not exactly 365.25 days in length — it's 365.2422 days long. Thus the Julian year runs about 11 minutes and 14 seconds longer than the tropical year. While that's not much of a discrepancy, it does add up: The Julian year had gained 8 days on the Sun by 1263 A.D., which pushed back the date of the vernal equinox from March 21 to March 13. This caused problems for Christians because the Council of Nicea had officially tied the date for Easter to a vernal equinox that occurred on March 21. It took roughly 300 years of agitation before the problem was corrected. In 1581 Pope Gregory XIII ordered the 10 days between October 4 and October 15, 1582 to be dropped. October 5 became, by papal edict, October 15. Leap years remained the same except for those century years not evenly divisible by 400. The vernal equinox was officially moved back to March 21. With this new calendar, three leap days in every 400 years would be taken out, bringing the error in the calendar down to 0.003 day per year, or three days every millennium.

Catholic countries were the first to accept this Gregorian calendar; the Protestant countries generally rejected it. They kept on the Julian calendar until 1752. Then the English decided to take action. The Earl of Chesterfield, the Earl of Macclesfield, and James Bradley, the Astronomer Royal, pushed a bill through Parliament in three months. By law, Wednesday, September 2 became Thursday, September 14. The September of 1752 became the shortest month in history — just 19 days long. Mobs rioted in Boston, crying, "Give us back our 11 days!" (Why all the fuss? Landlords were charging full rent for the missing days!)

The Eastern Orthodox countries still keep their religious dates with the calendar corrected by Caesar — although after World War I the U.S.S.R. adopted the Gregorian calendar. For civil international matters, the Gregorian calendar is used by all countries.

Today, our civil year contains 365 days and begins at midnight on December 31. Each tropical year begins at the instant when the mean Sun's right ascension equals 18h 40m. The beginning of the tropical year usually falls close to the beginning of the civil year. For instance, the year 1968.0 began astronomically at 1:07 a.m., January 1, on the civil calendar.

We've finally reached the point where our clocks no longer depend on our planet's uneven rotation or slightly eccentric orbit about the Sun. In fact, they provide such accurate time that we can actually measure the tiny variations in these historical timekeepers. To some extent, the National Bureau of Standards has to ruin this precision by tacking on an extra second now and then — just to keep our time systems in step with the Earth! Present methods of marking time's passage are incredibly reliable — and it will be a long time before we again need to eliminate 11 days from our calendar.

★Star 140

"precision optics you *can* take with you"

The STAR 140™ All-Purpose Telescope

Wherever you go, your STAR 140™ goes with you! Take it to the mountains, seashore, or use it in your own backyard. Big aperture for serious astronomy, yet portable enough that you'll always want to bring it along. Excellent views of the Moon and planets; superb for viewing nebulae and those rich Milky Way starfields. Ideal for deep-sky photography, too!

- big 5.5-inch aperture
- crisp, brilliant images
- wide 1.6° field of view
- handsome, durable epoxy finish
- mounts on any camera tripod

	PRICE	ORDER NUMBER
STAR 140™ Schmidt-Newtonian (telescope only)	**$434.95**	**SP101**
STAR 140™ telescope plus heavy photo tripod	**$534.95**	**SP102**
STAR 140™ telescope plus equatorial mounting	**$734.95**	**SP103**
Barlow Lens (doubles magnification)	**$ 59.95**	**SP104**
26mm precision Plössl Eyepiece	**$ 59.95**	**SP105**
Camera Adapter **(you must supply T-ring for your camera)**	**$ 29.95**	**SP106**
5 x 24 finder with ring mounts	**$ 24.95**	**SP115**

INTRODUCTORY PRICE!

SAVE ON OUR TELESCOPE/MOUNTING COMBINATION

$850.00 VALUE

OUR PRICE ONLY

$734.95

Technical Specifications, Optical: Schmidt-Newtonian optical system; 139.7 millimeter aperture; focal length: 508 millimeters; focal ratio: 3.64; laser-calibrated Schmidt corrector plate; 52 millimeter elliptical secondary mirror; full thickness Pyrex primary mirror; standard magnification: 28x; magnification with 26mm Plössl: 19.5x.
Technical Specifications, Mechanical: tube length 19 inches (480mm); tube diameter 6 inches (153mm); weight: 6.4 pounds (2.9 kg); aluminum tube construction; metal dust cover; high-precision ultra-smooth slide focuser with lockscrew; 1.25″ I.D. metal eyepiece drawtube (lockable); sturdy metal ¼″-20 tripod attachment plate; optional camera adapter, optional 5 x 24 finder with ring mounts.
Technical Specifications, Equatorial Mounting: manual right ascension slow motion with 90:1 reduction; manual declination slow motion; 2¾″ x 1⅜″ x-section wooden tripod, legs adjustable from 45 to 59 inches length; positive lockable latitude adjustment; fine adjust in azimuth; built-in bubble level; handy accessory tray; setting circles and locking clutch (both axes); adjustable counterweight; provision for polar axis alignment telescope (not included); felt-lined telescope rings.

★Star
PRODUCTS

Div. of AstroMedia Corp.
625 E. St. Paul Ave.
P.O. Box 92325
Milwaukee, WI 53202

Telescopes and accessories shipped promptly via U.P.S.

Sorry, but we cannot ship outside the U.S. except APO and FPO.

PHONE ORDERS AND INQUIRIES WELCOME.

(414) 276-7680

Send this coupon or a copy to: **STAR PRODUCTS™, Div. of AstroMedia Corp., 625 E. St. Paul Ave., P.O. Box 92325, Milwaukee, WI 53202. (414) 276-7680** Phone orders welcome.

☐ **SP101 $434.95** ☐ **SP102 $534.95** ☐ **SP103 $734.95**
☐ **SP104 $ 59.95** ☐ **SP105 $ 59.95** ☐ **SP106 $ 29.95** ☐ **SP115 $ 24.95**

Send me the items I have checked (✓) above.

Enclosed is my check/money order for $ ________.

Charge my credit card $ ____________.
☐ MasterCard ☐ VISA ☐ American Express

Card Number Exp. Date

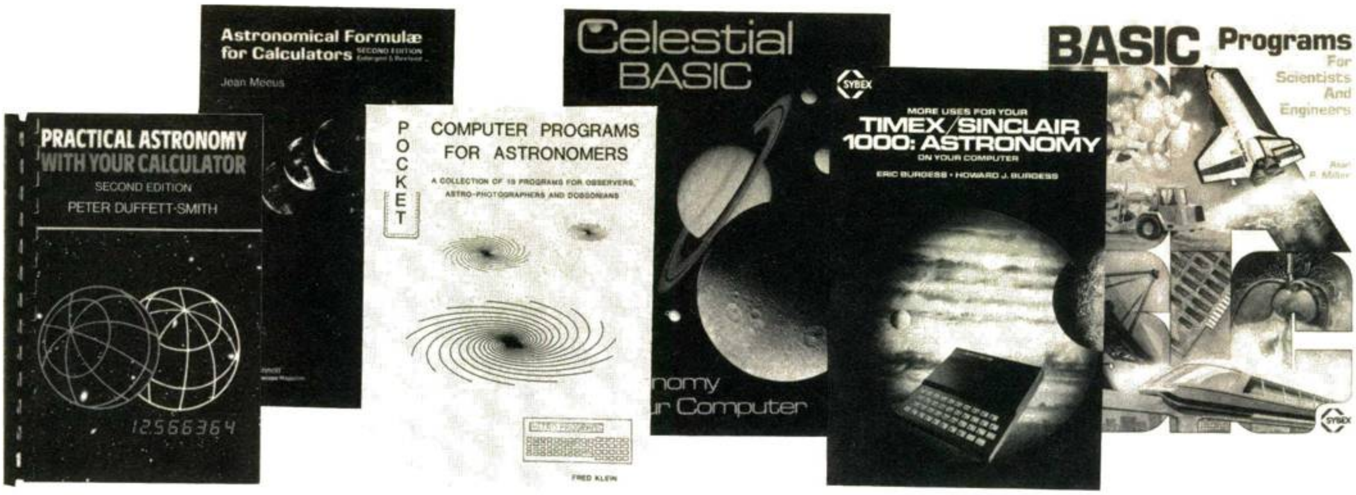
Signature Daytime Telephone Number

Name

Address

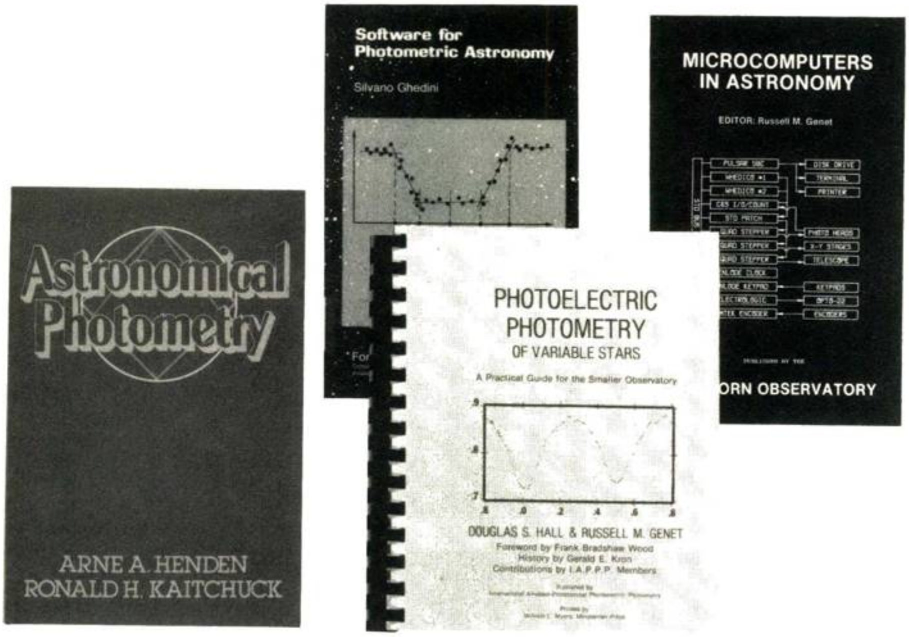
City State Zip

6514



PRACTICAL ASTRONOMY WITH YOUR CALCULATOR
SECOND EDITION
PETER DUFFETT-SMITH
Astronomical Formulæ for Calculators
Jean Meeus
POCKET COMPUTER PROGRAMS FOR ASTRONOMERS
FRED KLEIN
Celestial BASIC
MORE USES FOR YOUR TIMEX/SINCLAIR 1000: ASTRONOMY ON YOUR COMPUTER
ERIC BURGESS • HOWARD J. BURGESS
BASIC Programs For Scientists And Engineers
SYBEX

ASTRONOMY
SOFTWARE



Astronomical Photometry
ARNE A. HENDEN
RONALD H. KAITCHUCK
Software for Photometric Astronomy
Silvano Ghedini
MICROCOMPUTERS IN ASTRONOMY
EDITOR: Russell M. Genet
PHOTOELECTRIC PHOTOMETRY OF VARIABLE STARS
A Practical Guide for the Smaller Observatory
DOUGLAS S. HALL & RUSSELL M. GENET

Astronomical Photometry, by Arne A. Henden and Ronald H. Kaitchuck. Written at a college text level, covers the theoretical side of photometry. In addition to covering atmospheric extinction corrections, the UBV system, absolute calibration, and constructing photometers, it details the types of variable stars and why astronomers observe them. 392 pages, hardcover, **$30.95.**

Software for Photometric Astronomy, by Silvano Ghedini. You don't have to write your own software — Ghedini has already done it. Written in HP BASIC, the programs begin with air mass and extinction corrections, then leap to determining time of minimum light and period analysis of variables. 221 pages, paperback, **$27.50.**

Photoelectric Photometry of Variable Stars, by Douglas S. Hall and Russell M. Genet. A wealth of practical hands-on advice for photoelectric photometry — from using a photometer to data reduction. Descriptions of amateur observatories and addresses of suppliers and amateur organizations included. 281 pages, paperback, **$18.50.**

Microcomputers in Astronomy, ed. by Russell M. Genet. Thirty papers presented at the Fourth Fairborn Symposium detail the present state-of-the-art in applying microcomputers to automatic telescope control. An absolute must for everyone interested in controlling telescopes or photoelectric photometers by computer. 253 pages, paperback, **$23.95.**

Practical Astronomy With Your Calculator, 2nd ed., by Peter Duffett-Smith. Tells you how to use a scientific calculator to convert local standard time to sidereal time, find the time of moonrise and set — and more. Assumes no specialized knowledge, provides complete examples. 188 pages, paperback, **$10.50.**

Astronomical Formulae for Calculators, 2nd ed., by Jean Meeus. For the more mathematically advanced, provides formulae for you to write programs to determine the positions of the jovian moons, the principal perturbations affecting the planets — and lots more. Fully worked-out examples. 201 pages, paperback, **$15.50.**

Pocket Computer Programs For Astronomers, by Fred Klein. Contains 13 Pocket Computer BASIC programs for calculating altitudes and azimuths, jovian satellite positions, age and phases of the Moon, comet positions, and much more. Besides the programs, it also tells you how the programs work so you can customize them for machines other than the Pocket Computer. 100 pages, paperback, **$12.95.**

Celestial BASIC, by Eric Burgess. Written for Apple II computers, but modifiable to run on other machines. Includes programs for precessing star coordinates, phases of the Moon on any date, and far more. Makes use of the Apple's graphics capability. 300 pages, paperback, **$14.50.**

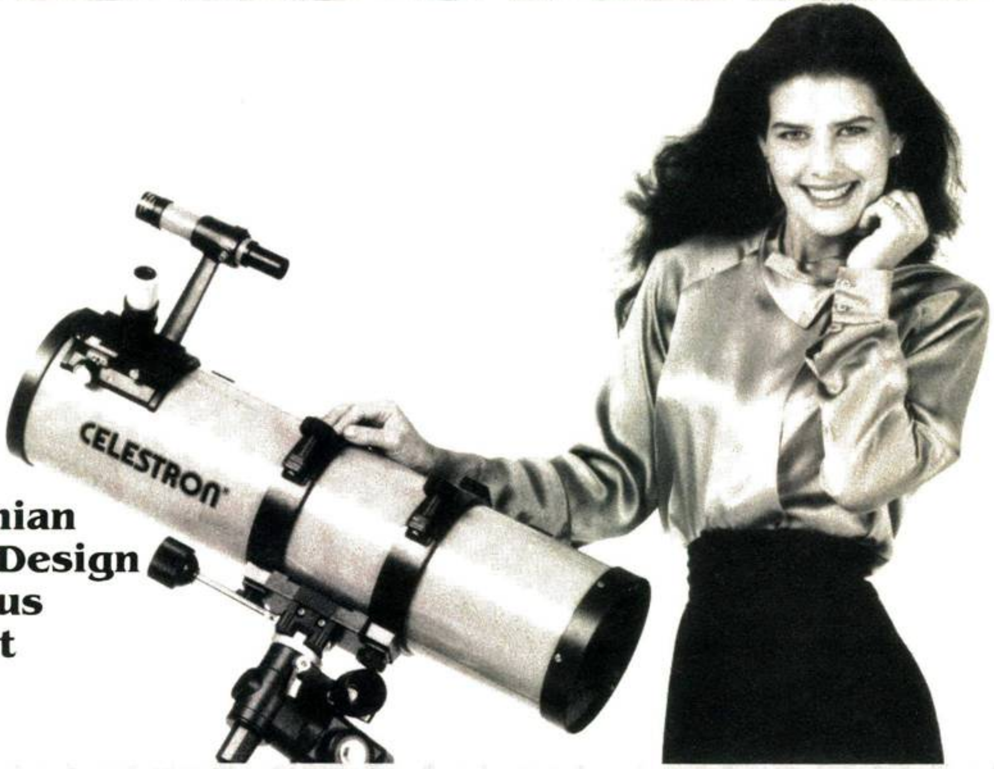
More Uses for Your Timex/Sinclair 1000: Astronomy on Your Computer, by Eric and Howard J. Burgess. Contains ready-to-run programs for calculating the right ascension and declination of the Sun, the Moon, and all the planets for any date, the positions of Jupiter's Galilean satellites, elongations and phases for Mercury and Venus, and much more! 153 pages, paperback, **$9.50.**

BASIC Programs for Scientists and Engineers, by Alan R. Miller. A cookbook of mathematical routines. Includes matrix multiplication and division, solving equations, how to find a best-fit curve, sorting, numerical integration, and how to evaluate your BASIC interpreter. 318 pages, paperback, **$16.50.**

To order, use the AstroMedia order form bound into this magazine or send to AstroMedia Order Dept., P.O. Box 92788, Milwaukee, WI 53202.

Foreign orders, add $2.50.

NEWTON WOULD BE ASTOUNDED



Celestron's New C6 Newtonian Offers Classic Design Advantages Plus State-of-the-Art Advances

The Classical Newtonian Reflector offers excellent light-gathering ability, wide field of view, good portability and excellent price. The Newtonian design has not been significantly improved upon since 1668. Celestron's new Classic C6 Newtonian is a telescope that Sir Isaac would instantly recognize at a distance. But up close, he would be astounded.

The C6 is no ordinary 6" Newtonian. It is the best Newtonian ever manufactured. It features multi-coated mirror surfaces for 20% greater reflectivity than ordinary 6" Newtonians. Celestron quality diffraction limited optics. It offers an f/5 ratio for outstanding brightness and fantastic ease in astrophotography. An incredible high-contrast 26mm Plössl eyepiece. An equatorial mount with slow-motion controls, setting circles on both axes, adjustable threaded counterweight, azimuth and elevation adjustment and a tripod with easy height adjustment and accessory tray. Plus a fully achromatic wide-angle 6X30 finderscope.

But there's more. Including an optional IC controlled quartz pulse motor drive with drive corrector. And optional Polar Axis Finder Scope for precision polar alignment in minutes. A whole world-renowned Celestron line of adaptors, oculars, mounts, filters and accessories.

And a 25-year limited warranty as good as our name.

An ordinary Newtonian 6" is a good telescope at a great price. The new Celestron is a great improvement at a great price. Find out more. Contact your nearest Celestron Dealer.

CELESTRON®
PRECISION OPTICS

For Dealer Locations, Catalogs, Information, Technical Data Sheets

CALL FREE 1-800-421-1526

(Mon-Fri; 8-4:00 Pacific Time; Continental USA only)

CELESTRON INTERNATIONAL, P.O. Box 3578 B11, 2835 Columbia St., Torrance, CA 90503 (213) 328-9560

The telescope price leader lowers its prices while other manufacturers raise theirs.

Our competition has raised its telescope prices as much as 28% in the last year—yet we have lowered ours while further improving the quality demanded of Odyssey.

Enjoy the proven performance of these precision telescopes with the breathtaking ability to reveal the universe. Lower prices than many telescopes having only a fraction of their capability, the Odyssey series brings you the universe like no other.

SAVE $200
ODYSSEY 17" Was $1,195
NOW $995

ODYSSEY COMPACT
10.1" $299.50

ODYSSEY 1
13.1" $499.50

ODYSSEY 2
17.5" $995.00

THE WORLD'S BIGGEST production telescope. And sold for less than the optics alone elsewhere: $3,495.

ODYSSEY 29"
$3,495.00

Reach Into Depths Of The Universe

WE IMPROVED THE WAY YOU SEE THE UNIVERSE

The sturdy, stable Odyssey series is still unbeatable for aperture size, price and optical quality. And we still lead the way with dramatic new concepts which have revolutionized amateur observer telescopes.

PRECISION OPTICS. Every Odyssey mirror optic is tested to beat anything in the field for brilliant, quality imagery.

SIZE. Odyssey telescopes offer you mirror diameters which let you get serious about exploring distant galaxies. You can now see the universe up-close as it really is.

EXPERIENCE THE UNIVERSE IN VISUAL HIGH-FIDELITY

Don't settle for less. Don't pay more. Odyssey shows you a visually equalized universe-the correct size-to-brightness relationship of all objects viewed through a telescope.

SPECIFICATIONS

All Odyssey telescopes feature:

★ Paraboloidal Pyrex mirror, null figured to ⅛th wave, aluminized & overcoated.
★ Super smooth and stable Dobsonian alt-azimuth mount with Teflon bearings throughout.
★ No play or backlash.
★ Special mirror support systems.
★ Adjustable collimation.
★ Coated, high-performance 27mm Kellner eyepiece with 1¼ inch rack-and-pinion focuser.
★ Ready to use with Blue Zolatone finish.

DOBSONIAN Headquarters

Large Aperture Lightweight Mirror Optics

The emphasis is on performance with these truly revolutionary lightweight mirror optics. You now can build the light, compact large aperture telescope you have always wanted.

Mirrors can be mounted as standard, flat-back or on flotation cells. There are complete instructions with these null figured, ⅛ wave paraboloidal Pyrex mirrors. All are aluminized and over-coated, free of astigmatism, with approximately 13 - 1 diameter-to-thickness ratios. Your satisfaction is guaranteed.

Massive Observatory-size Optics

29 inch f/4.5 mirror	$2490.00 16-1 Ratio
17.5 inch f/4.5 mirror	$ 659.50 13-1 Ratio

Now you can see virtually every NGC object. Faint, undefinable shapes appear in startling detail. Includes diagonal.

Lightweight Mirror Optics at Low, Low Prices:

13.1 inch f/4.5 mirror	$254.50
12.5 inch f/6 mirror	$249.50
12.5 inch f/4.5 mirror	$259.50
10.1 inch f/4.5 mirror	$134.50
10 inch f/5.6 mirror	$129.50

SHIPPING: Optics prices include shipping in the 48 contiguous states. Shipping to other destinations is additional.

Pyrex Mirror Blanks for Dobsonian Telescopes—Diamond Edged

10 inch x 1⅛	$ 49.50
12.5 inch x 1⅛	$ 79.50
13.1 inch x 1⅛	$ 89.50
17.5 inch x 1 5/8	$249.50
20 inch x 1 5/8	$395.00
22 inch x 1 5/8	$495.00
24 inch x 1 5/8	$750.00
29 inch x 1 5/8	$899.00

Elliptical Diagonals

These coated flats are ready to mount and use. This wide selection is low priced. Guaranteed 1/10 wave. Select the minor axis you need:

1.83" — $15.50	3.10" — $34.50
2.14" — $18.95	4.25" — $69.50
2.60" — $22.50	6.25" — $150.00

(Shipping charge payable upon delivery, F.O.B. Idyllwild, CA. Prices include crating. California residents please add 6% sales tax.)

ODYSSEY

Coulter Optical Co.

Dept. A P.O. Box K, Idyllwild, CA 92349 (714) 659-4621

Visit our showroom at 54141 Pinecrest Road in Idyllwild, one of California's premiere mountain resort communities

VISA

STAR PRODUCTS

BINOCULARS FOR EVERY OBSERVER!

SEE MORE WITH OUR GIANT BINOCULARS

Quality Features Found In These 80mm Binoculars:

- big 80mm achromatic objective lenses
- fully coated optics
- maximum image sharpness and contrast
- center knob for quick and easy focus
- quality optics from Celestron
- 25-year warranty
- 11½ inches high and under 5½ lbs. each
- tough black plastic finish

11x80 Country-Sky Binoculars

For the widest, brightest experiences in deep-sky observing, we recommend 11x80 binoculars. Why? Their tremendous light grasp coupled with their wide field of view will show you large faint nebulae and the glittering star clouds of the Milky Way better than small binoculars or high power telescopes. Tripod recommended for best results. Wide 4.5 degree field of view, extra-large 7.3mm exit pupil.

11x80s	**(without tripod)**
SP111	**$255.00**
11x80s	**with tripod**
SP112	**$335.00**

20x80 For Greater Magnification

Imagine the sparkling Pleiades imaged in the powerful twin optical systems of these big binoculars! Higher magnification brings out fainter stars and finer detail — excellent for viewing brighter Messier objects and for general astronomy. We recommend these as superior for city observing. Tripod recommended. 3.5 degree field of view, 4mm exit pupil for sharp performance.

20x80s	**(without tripod)**
SP113	**$270.00**
20x80s	**with tripod**
SP114	**$350.00**

We regret that we can sell this sturdy tripod only with binocular orders.

Every giant binocular comes complete with a heavy duty carrying case, shoulder carry-strap for case, Photo-Tripod Adapter (fits all tripods), and objective and eyepiece lens caps.

BUSHNELL BINOCULARS

7x35 ➤

The all-around glass — light, compact, sturdy, portable. Perfect for beginning astronomers, excellent for sports, sailing, racing, hunting as well. 9.5° field of view; 5mm exit pupil; 4⅞" high; 17 ounces.

SP108 . . . . $51.95

◄ 7x50

The traditional choice for amateur astronomers. Fantastic light grasp; 7° field of view; huge 7mm exit pupil. 7" high; weighs 27 ounces.

SP109 . . . . $64.95

10x50 ➤

Heavier than 7x50s, 10x50s offer more magnification and better definition. Wide angle eyepiece covers magnificent 8° field of view. 38 ounces; 6⅛" high; 5mm exit pupil.

SP110 . . . $169.95

All Bushnell binoculars come with carrying case and straps and feature Insta-Focus for fast, one-hand focusing. Plus a limited lifetime warranty.

STAR PRODUCTS

Div. of AstroMedia Corp.
625 E. St. Paul Ave.
P.O. Box 92325
Milwaukee, WI 53202

Binoculars and accessories shipped promptly via U.P.S.

Sorry, but we cannot ship outside the U.S. except APO and FPO.

PHONE ORDERS AND INQUIRIES WELCOME.

(414) 276-7680

Send this coupon or a copy to: **STAR PRODUCTS™, Div. of AstroMedia Corp., 625 E. St. Paul Ave., P.O. Box 92325, Milwaukee, WI 53202. (414) 276-7680** Phone orders welcome.

☐ **SP108 $ 51.95** ☐ **SP109 $ 64.95** ☐ **SP110 $169.95**
☐ **SP111 $255.00** ☐ **SP112 $335.00** ☐ **SP113 $270.00** ☐ **SP114 $350.00**

Send me the items I have checked (✓) above.

Enclosed is my check/money order for $ ________.

Charge my credit card $ ____________.
☐ MasterCard ☐ VISA ☐ American Express

Card Number ______________________ Exp. Date

Signature ______________________ ( ) Daytime Telephone Number

Name ______________________

Address ______________________

City ______________________ State Zip

6S14

ASTRONEWS

Possible Black Dwarf Identified

Observational astronomy is, by nature, structured toward finding objects that are luminous. In the case of very small stars with less than 0.085 solar mass (about 100 times the mass of Jupiter), this poses a severe technical problem for researchers. After such stars form, they contract and convert a modest amount of gravitational energy into an equally modest amount of heat — and never become hot enough to begin fusion of their hydrogen. When they have contracted as far as they can, they stop generating heat. Such objects — called black dwarfs — are extremely faint stars that cool off slowly over billions of years.

If many black dwarfs existed, they would add a lot of mass to the universe — but so far astronomers have not found an undisputed example of one. Now, however, Ronald Probst of NASA's Ames Research Center and James Liebert of the University of Arizona's Steward Observatory report that the very faint star LHS 2924 in the constellation Bootes may well be a black dwarf.

Writing in the *Astrophysical Journal*, they report that the energy distribution in the star's spectrum indicates a very cool object, with a temperature of only 1950 ± 150° K. But the spectrum is peculiar, because the optical flux is greater than expected for such a cool, very red dwarf. The spectrum shows much weaker lines of titanium oxide and calcium hydroxide as compared with the spectra of very cool red dwarfs. The scientists call LHS 2924's energy distribution and spectrum "confusing, contradictory, and unprecedented for a very red [nearby] star."

Probst and Liebert considered the possibility that LHS 2924 is an old white dwarf that has cooled, a dust-shrouded red dwarf, or a late red subdwarf, but rejected these possibilities as contradicting the observed spectrum. Instead, they argue that LHS 2924 is probably a black dwarf.

Fortunately, LHS 2924 is on a parallax-determination survey program now being conducted by David Monet of Mt. Wilson Observatory and Conrad Dahn of the U.S. Naval Observatory. Monet and Dahn report a preliminary distance for LHS 2924 of 28 light-years, which yields an absolute magnitude of 20.0 for the star. This makes 2924 the intrinsically faintest star known, surpassing the previous record-holders, VB 10 (absolute magnitude 18.7, discovered in 1944) and RG 0050-2722 (absolute magnitude 19 ± 1, discovered in 1981).

Although Probst and Liebert base their argument on LHS 2924's spectrum, the extreme intrinsic faintness of the star is further strong evidence that LHS 2924 is a black dwarf. In a special note added to their paper, Probst and Liebert write, "This eliminates all possibilities other than a single cool low-mass object, and places LHS 2924 in the [black dwarf] regime of the HR diagram." Incidentally, both VB 10 and RG 0050-2722 may be black dwarfs as well.

If LHS 2924 really is a black dwarf, it should be young, since black dwarfs fade from view as they age and cool down. An old black dwarf would be even fainter than LHS 2924 and probably undetectable with present technology. Age suggests another test, since young objects in the Milky Way generally orbit the galactic center in nearly circular orbits confined to the plane of the Galaxy.

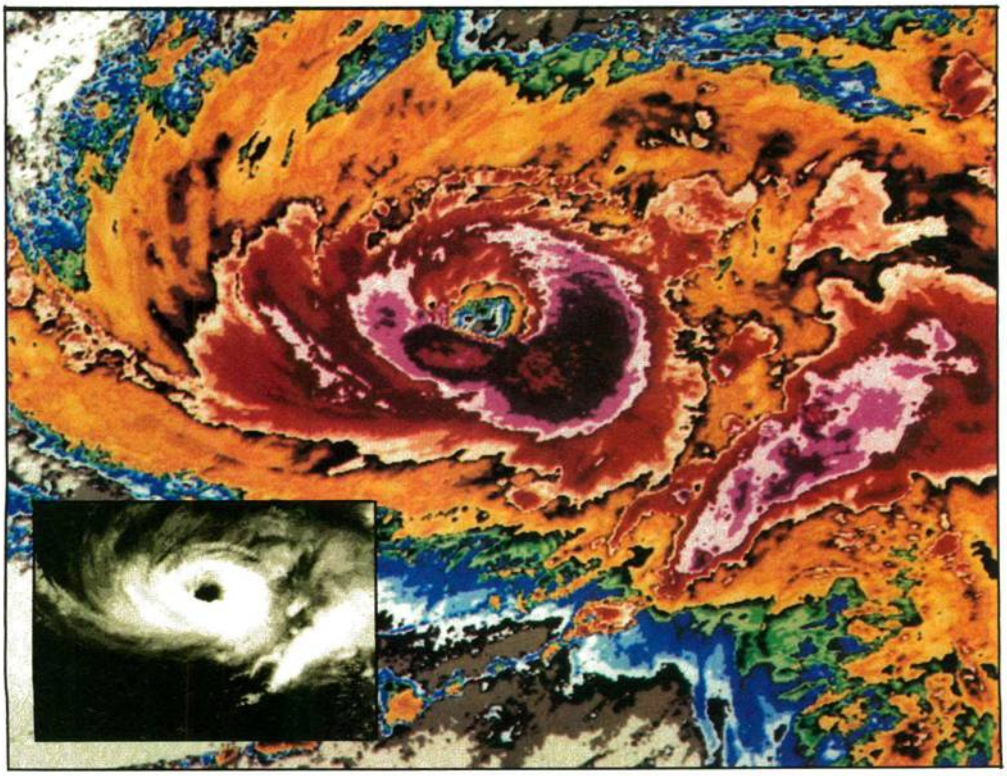
Does LHS 2924's motion suggest it is young? Unfortunately, we don't yet know. From the star's proper motion and distance, we can deduce its tangential velocity — the velocity across our line of sight. But in order to determine the total velocity, we also need its velocity along our line of sight. Astronomers can easily determine this radial velocity by observing the Doppler shift in its spectral lines, but so far no one has done it. LHS 2924's tangential velocity is consistent with the star's being young, but until we know the radial velocity, we won't know for sure whether the space motion of LHS 2924 indicates a young star. *Ken Croswell.*

Space Medicine Aboard Spacelab

Since medical considerations are of particular importance to long-term human adaptation to space, they will receive lots of attention in ESA's Spacelab, a special research facility to be launched aboard NASA's Space Shuttle. Spacelab provides pressurized modules and unpressurized equipment mounting platforms called pallets. Within the shirtsleeves comfort of the main unit shell, astronauts will operate an ambitious science program. Much of the wall-to-wall equipment is devoted to life sciences.

The MicroGravity Program forms a major part of the life science experiments. The Biorack unit will be one of the major pieces of hardware supporting the program. Biorack is a multipurpose facility for investigating the biology of plants, tissues, cells, bacteria, and insects. Its main purpose will be to study the effects of near weightlessness and high-energy cosmic radiation on the development and behavior of these specimens. Biorack also carries facilities for duplicating the same experiments under simulated 1 G conditions during the actual mission to permit separating the biological effects of gravity from the effects of radiation. In addition the unit will support two incubators, a cooling and freezing unit, and a filtered-air glove box system to prevent contamination of both specimens and crew.

Biological theories as yet unconfirmed by Earth-based experiments have been earmarked



NOAA

About 10 hours before Hurricane Alicia hit the Texas coast, the NOAA-7 satellite recorded this infrared image. A computer added the colors to reveal temperature differences as small as 5°Kelvin. The warm waters of the Gulf of Mexico show up as grey and light blue; the storm's coldest clouds appear deep purple. Alicia's eye, about 30 miles across, appears in the center. It was 60 miles south of Galveston when this picture was taken. Inset: NOAA-7 unenhanced image.

REFRACTING TELESCOPES

5 MODELS NOW AT YOUR CELESTRON DEALER!

C60 • C70 • C80 • C100 • C100E

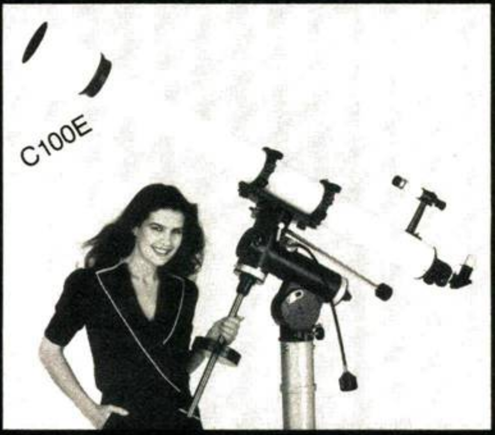
C80
80mm Equatorial
Refractor
• Optional Quartz Controlled Motor
• Optional Polar Alignment Telescope
Incredible Resolution From Precision Objective Lens
Dew Cap
CELESTRON
6x30 Standard Finderscope
Setting Circles
Ultra Stable Equatorial Mount
Quality 1¼" Oculars
Slow-Motion Controls and Azimuth/ Altitude Adjustments
Adjustable Tripod

• ALL SIZES • ALL PRICE RANGES • VISUAL AND PHOTOGRAPHIC

A refractor is usually the amateur's first telescope and what the "average person" expects a telescope to be. Fortunately, not all refractors are alike.

Celestron, the world's largest manufacturer/supplier of quality telescopes, is proud to unveil a new series of *quality* refracting telescopes. Why? A quality refracting telescope from Celestron is economical; portable; adaptable for 35mm and video photography; and will give you a superb high contrast - high definition images. Refractors are excellent telescopes for solar, lunar, planetary and double star observations; they also give high contrast views of deep sky objects. Celestron refractors are not "toy" telescopes. A quality Celestron achromatic refractor has precision optics, a stable equatorial mount, an adjustable tripod. Optional accessories include a Pulse Motor Drive (with worm gear) that is controlled by an integrated circuit and a precision quartz oscillator. Each Celestron refractor can be utilized for simple observation or for photography - it's a system that will grow with your interests. Celestron backs its refractors with a 25-year warranty.

There are a lot of reasons to get a Celestron, but the best reason is what you can see through one. We invite you to take a look through a Celestron at your local Celestron dealer.



Questions? Call Celestron's Telescope Information Service Toll Free Continental USA Only

1-800-421-1526

Please call or write for dealer locations, catalogs or technical specifications

CELESTRON INTERNATIONAL - P.O. Box 3578-B - 2835 Columbia Street - Torrance, CA 90503 (213) 328-9560

PRECISION OPTICS FROM CELESTRON®

for special attention. Experiments flown aboard the Soviet Union's Salyut 6 showed increased cell proliferation in culture media, but whether this was a result of weightlessness or cosmic radiation was not established. Biorack will provide the first opportunity to discriminate, and by doing so to ascertain what effects weightlessness will have on long-mission astronauts. Additionally, it has been found that some white blood cells (lymphocytes), multiply more quickly under increased g-levels and more slowly under weightless conditions. Such cells form an important part of the body's immune system; because of these findings great emphasis has been placed on discovering how the human body can cope with disease following long-term exposure to weightlessness.

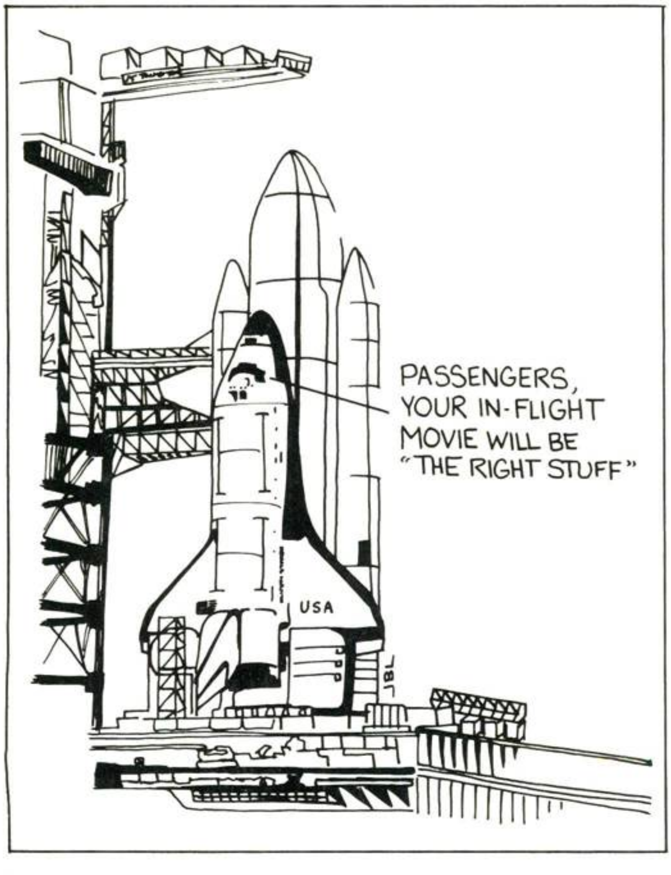
Cell resistance will be studied to determine how bacteria react to antibiotics and other drugs under weightlessness. If it is found, for example, that the treatment of infections is precluded by weightlessness, then alternative measures will have to be found to ensure that an astronaut's simple cold does not turn into pneumonia.

Researchers will also monitor biological "clocks." Earth-based lab tests with a clinostat (which simulates weightlessness) indicate that biorhythmic cycles lengthen under weightlessness.

Of major significance to the near-future small-scale colonization of space is how space environments affect the development of plants, animals, insects, and even human beings. But ultimately, Biorack experiments seek to discover the pathological and physiological problems that might confront long-term astronauts and remedies to offset such biological difficulties.

Biorack is scheduled for launch aboard the German Spacelab D-1 in 1985. However, an experiment package named Anthrorack, designed for testing and examining human beings, will fly first. Anthrorack came about because of the huge response to the preliminary call for experiments for the first and second Spacelab missions.

The research areas which attracted most attention concern the biological effects of gravity on humans. The physiological experimentation will test cardiovascular, renal, and endocrine systems, the distribution of bodily fluids, blood, plasma, and bone/muscle alterations. A number of these changes occur rapidly, but disappear quickly on return to Earth. Others develop more slowly — and there is valid concern that as missions increase in duration, irreversible bodily changes might well occur, particularly to the skeletal and immune systems.



Anthrorack holds many instruments applicable to specific areas of study. Each experiment — echocardiograph, freezer/cooler, respiratory gas analysis system, video recorders, sensor amplifiers, ergonometer control unit — requires installation within a double rack similar to a large-size modular hi-fi rack. Instruments within the unit itself will be interchangeable, but large associated items (such as the Space Sled) and storage items will, of necessity, be fixed.

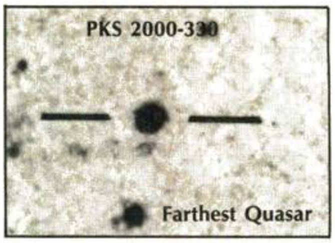
The Space Sled unit consists of a seat attached to a rail track, which is fixed to the floor of the module. The seat can swivel forward, sideways or upward, and move back and forth along the length of the module. It may be accelerated at controlled rates to establish what effect controlled movement has on animals or crew members. Experimenters hope the Sled will lead to an understanding of what space sickness is and how weightlessness affects human orientation and sense of motion.

The Space Sled will be in use constantly. It forms part of a far larger research program into the effects of zero-g, which will be integrated into both Biorack and Anthrorack. Both of these flexible modular systems have been loaded with experiments before launch and managed by the crew, either automatically or semi-automatically.

Thus even the first Spacelab mission launched aboard the Shuttle will provide a stepping-stone to a more substantial program of research — a program that will ultimately include numerous experiments. It will lead later missions to an understanding of the physiological difficulties that now prevent humans from turning their steps toward space with confidence. *Aldo G. Rabaiotti.*

Quasars and Cosmic History

The enormous number of sharp, dark absorption lines in the spectra of quasars, dubbed the "Lyman-alpha forest" by astronomers, may provide a new probe to conditions in the early universe. Astronomers at the California Institute of Technology and University College, London, found that the number of dark absorption lines increases for more distant — hence more ancient — quasars. The spectral lines form when quasar light passes through numerous intergalactic clouds of hydrogen on its journey to Earth. The astronomers concluded that either there were many more hydrogen clouds in the distant past or ancient clouds were much larger than those observed today.



At a recent symposium on quasars and gravitational lenses held in Liege, Belgium, Caltech astronomer Wallace Sargent and Alec Boksenberg of University College, presented evidence that these primordial clouds show evolution over cosmic time scales. The cloud changes represent only the third clear-cut example of evolutionary behavior over time periods comparable to the age of the universe. The other two examples have come from studies of quasars and distant radio galaxies.

Sargent and Boksenberg also found that the clouds are almost entirely pure hydrogen, which implies that they are remnants of the original material of the universe, uncontaminated with elements created by the hydrogen fusion that takes place in stars. The researchers expect that careful examination of how greatly the clouds deviate from being pure hydrogen will provide valuable insights into conditions at the moment of the Big Bang — the cosmic explosion some 18 billion years ago that cosmologists postulate as the beginning of the universe.

Quasars emit a large amount of radiation at the wavelength of hydrogen's Lyman-alpha spectral line. In the laboratory, Lyman-alpha radiation occurs in the ultraviolet region of the spectrum, but the light from enormously distant, rapidly receding quasars is redshifted so much that the Lyman-alpha line arrives at Earth in the visible part of the spectrum. Redshift is the change toward longer wavelengths, or reddish color, of light from a receding source, a phenomenon which astronomers use as a "cosmic yardstick." Astronomers have found that the greater an object's redshift — that is, the faster it is receding — the farther off it is. By using known relationships between speed of

GLOBES FROM ASTRONOMY

Manufactured by Replogle, these make fine additions to home, office, classroom or library.

NASA Moon Globe

Official 12″ globe with NASA-approved accuracy. Extremely detailed, it almost puts you on the surface of the Moon! Rests on a molded base and comes complete with booklet and study projects.

15″ high $26.95

The Apollo

12″ celestial globe shows 1,200 stars to 4th magnitude. Includes clusters, novae, doubles and the Milky Way! Gyromatic mounting in silver finish, complete with illustrated booklet.

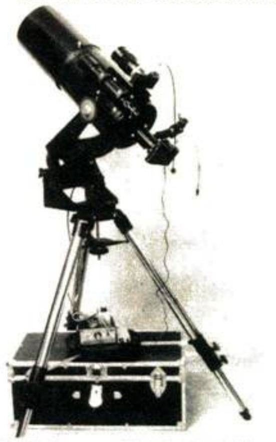
16½″ high $28.95

To order, use the AstroMedia order form bound into this magazine or send to: AstroMedia Corp., Order Dept., P.O. Box 92788, Milwaukee, WI 53202. Sorry, but we cannot ship globes outside the U.S. except APO or FPO.

MEADE TELESCOPES AT LUMICON

LUMICON carries a full line of Meade Telescopes and accessories. Meade catalogue $3. Call 415-447-9570 for information or orders.

HIGH PERFORMANCE SCHMIDT-CASSEGRAINS



High Performance 8″f/10 Meade 2080LX telescope system: (optional EASY-GUIDER, drive corrector, 200mm telephoto shown), includes high precision worm gear ideal for astrophotography (10 arc-second periodic error), 8X50mm finderscope, high transmission coatings, equatorial wedge, adjustable Meade field tripod, dew shield, accessory shelf, no-tool knob set, 7mm orthoscopic & 20mm research grade Erfle eyepieces, all standard accessories ($1759 value) . . **$1295**

($1250 if purchased before Dec. 31, 1983)

LUMICON Cassegrain EASY-GUIDER™
Rich-Field View combination ($216) . . . **$198**
Dual-axis Drive Corrector with electric declination **$275**
Deluxe Piggback bracket, adjustable . . . $35

Meade Telescope Systems with worm gear drive, 6X30mm finderscope, 80X, 220X eyepieces, fork mount, carrying case.
Meade 2080 8″f/10 telescope **$829**
Meade 2080LX with special high precision worm gear drive for astrophotography . **$899**
Meade 2120LX, 10″f/10 w/LX drive . . . **$1795**
Special coatings: 8″ . . . . **$79**, 10″ **$140**
Dew Shields: 4″ . . **$42**, 8″ . . **$65**, 10″ . . **$88**
Solar Filter: 4″ . . **$108**, 8″ . . **$99**, 10″ . . **$139**
Meade heavy duty adjustable field tripod **$195**
Equatorial Wedge: 4″ or 8″ . . **$69**, 10″ . . **$98**
LUMICON Cassegrain EASY-GUIDER/Rich-Field Viewer combination ($216) . . **add $198**
LUMICON Deluxe Rich-Field Viewer system w/ 32mm Tele Vue Plossl, 1.5° true field . **$169**
LUMICON 1¼″ UHC Filter for unsurpassed views of planetary & emission nebulae . **$79**
LUMICON Premium 1¼″ Deep-Sky Filter improve view of **all** deep-sky objects (reg. price $79.50) **$69**

New Meade Model 2044 4″f/10 complete telescope system with motor drive, setting circles, special coatings, manual slow motion controls, table tripod, standard 1¼″ accessories (40X, 110X eyepieces) ($845 List price) **$650**
Accessories for 2044 — See above.

Shipping added to telescopes, charge orders. Prices may change w/o notice.

LUMICON 2111 Research Drive, #5A
Livermore, CA 94550 (415) 447-9570

TeleVue™

. . . Even better than you imagined!

VUE 24MM WIDE FIELD

TELE VUE 65° WIDE FIELD EYEPIECES

PAT. PEND.

19mm 24mm
32mm (2″) 40mm (2″)

"FIRST WIDE ANGLE EYEPIECE WITH SNAP IMAGING"

—John Vogt, NY

VUE 32MM PLOSS

TELE VUE 50° PLÖSSL EYEPIECES

PAT. PEND.

7.4mm 10.4mm 13mm 17mm 21mm 26mm 32mm 40mm
55mm (2″ BARREL) and 2.5x BARLOW

"SHARPEST I'VE EVER USED"

—From Review in Aug. 81 "ASTRONOMY"

TELE VUE NAGLER

TELE VUE 82° NAGLER EYEPIECES

U.S. PATENT
4,286,844

4.8mm 9mm 13mm

"THE NAGLER 13 —
— A REMARKABLE TELESCOPE EYEPIECE"

Title of 8 Page Article in "TELESCOPE MAKING" Magazine, Issue #20, Fall '83

Ask any owner or Tele Vue Dealer why Tele Vue eyepieces provide the most exciting views you've ever seen, regardless of size or type of telescope. Guaranteed superior!

Send now for our free color literature that shows you how to choose the best eyepieces for your telescope. We also make 2″ diagonals with adapters for Meade and Celestron scopes and focussing Questar adapters.

TeleVue 15-A GREEN HILL LANE, SPRING VALLEY, N.Y. 10977

PH. 914 · 354-4262

ASTRO NEWS

recession and distance, they can use an object's redshift to deduce its distance from Earth.

Sargent and Boksenberg demonstrated that on the "blue side" of the quasar's Lyman-alpha emission there are numerous distinct absorption lines, the so-called "forest." These lines are created when quasar light passes through the hydrogen gas clouds, which preferentially absorb the Lyman-alpha photons.

The astronomers were able to discern individual clouds along the route from the quasar to Earth because each cloud produces its own distinctive absorption line in the forest of the quasar's ultraviolet spectrum. Each cloud produces a distinct spectral line because each one has a unique velocity relative to the quasar — each cloud "sees" the Lyman-alpha light shifted to a uniquely different wavelength. The lines all appear blueward of the quasar's emission because they are nearer to Earth, hence less redshifted, than the quasar.

Significantly, the researchers found that the farther away the quasar, the more absorption lines appear in its spectrum. Looking at more distant quasars is a means of probing the past since it takes billions of years for the quasar's light to reach us.

Thus Sargent and Boksenberg concluded that the greater number of lines in the spectra of more distant quasars indicates that there were many more clouds of absorbing hydrogen in the past than in more recent times.

"By extrapolating our findings to the present epoch," notes Sargent, "we expect not to see many of these clouds. And in fact, 3C 273, a fairly nearby quasar, does not show any absorption lines caused by the clouds."

The astronomers also find that the clouds do not cluster in space; rather, they are more or less uniformly distributed. This contrasts with the behavior of galaxies. "This implies that these clouds are objects that avoid galaxies," says Sargent. "Places where galaxies form don't have these objects."

The astronomers' study sets very low limits on the amount of heavy-element material that could be present in the clouds — the clouds are nearly pure hydrogen and so are probably primordial. Following the fireball of the Big Bang, the universe consisted exclusively of hydrogen, deuterium, helium, and lithium, with the overwhelming percentage of the material — about 75 percent — being hydrogen. All heavier elements were created later as material was processed through the nuclear furnaces of stars.

By studying the relative abundance of deuterium compared to hydrogen, for example, astronomers can derive specific indications of the conditions in the Big Bang. So far, such an analysis has been hampered by the lack of a purely primordial sample. These intergalactic hydrogen clouds provide such a sample, and Sargent and Boksenberg are confident that further studies of the clouds will yield new insights into the fiery birth of the cosmos.

ASTRO CALENDAR

January 8-11	**163rd Meeting of the American Astronomical Society** (professional meeting), Las Vegas, Nevada. Sponsored by the University of Nevada-Las Vegas. Contact: AAS, 1816 Jefferson Pl., N.W., Washington, DC 20036.
February 17-19	**"Astron" Exhibition/Congress,** Milan, Italy. Contact: Comis Lombardia, Via Boccaccio 7, 20123 Milan, Italy.
March 3	**Seminar in Electronics Oriented Astronomy,** Cypress College, Cypress, California. Sponsored by Orange County Astronomers. Contact (send SASE): Orange County Astronomers, 2215 Martha Ave., Orange, CA 92667. Phone John Sanford, (714) 639-8446 or Harry Miller, (714) 637-8870.
March 12-16	**Fifteenth Lunar Planetary Science Conference** (professional meeting). Johnson Space Center, Houston, Texas. Contact: 15th LPSC, Lunar and Planetary Institute, 3303 NASA Road 1, Houston, TX 77058.
April 5-8	**National Meeting of the National Science Teachers Association,** Boston, Massachusetts. Contact: N.S.T.A., 1742 Connecticut Ave., Washington, DC 20009. Phone (202) 328-5800.
May 5	**Astronomy Day.** For more information, contact: Gary Tomlinson, Astronomy Day Coordinator, Astronomical League, Chaffee Planetarium, 54 Jefferson S.E., Grand Rapids, MI 49503. Phone (616) 456-3985. The Astronomical Association of Northern California will be hosting Astronomy Day on April 7.
May 30-June 3	**Texas Star Party,** Fort Davis, Texas. Contact: TSP '84, Dept. A, 128 N. Commerce, Burleson, TX 76028.
July 12-14	**Microcomputers in Astronomy II.** Fifth annual IAPPP-Fairborn Symposium, Fairborn, Ohio. Contact Russell M. Genet, Fairborn Observatory, 1247 Folk Rd., Fairborn, OH 45324.
August	**6th World General Assembly of International Union of Amateur Astronomers.** Bologna, Italy. Contact: Dr. Luigi Baldinelli, c/o A.A.B., Casella Postale 1630 AD, 1-40100 Bologna BO, Italy.
August 1-4	**ALCON 84,** National Convention of the Astronomical League. Carroll College, Waukesha, Wisconsin. Hosted by Milwaukee Astronomical Society. Contact: ALCON 84, P.O. Box 725, Mequon, WI 53092.
August 6-10	**Spitz Space Systems' Summer Institute in Planetarium Education,** Chadds Ford, Pennsylvania. Contact: 1984 Planetarium Summer Institute, Spitz Space Systems, Inc., Route One, Chadds Ford, PA 19317.
August 17-18	**Near-IR and Solid-State Photometry Symposium,** Lowell, Michigan. Hosted by IAPPP and Optec. Contact: Russell M. Genet, Fairborn Observatory, 1247 Folk Rd., Fairborn, OH 45324.

Meeting notices to appear in AstroCalendar must be submitted at least four months in advance of the meeting date. Most organizations appreciate your enclosing a long (business-size) self-addressed, stamped envelope along with your request for information.

ASTROMART

AstroMart listings are free to all our readers, but we can allow only 2 per person per year. Limit your ad to 40 words including your name and address and allow 4 to 6 months for it to appear. All ads are subject to review for suitability. AstroMedia assumes no responsibility for statements made in classified ads, nor for the quality of advertised items.

FOR SALE — Coulter Odyssey 1 telescope, 13.1", f/4.5. In very good condition, $600 firm. You pick up. Contact Stephen Amerongen, 8201 — 151 St., Edmonton, Alberta, Canada T5R 1H5.

FOR SALE — Celestron 14, excellent condition, observatory housed, standard equipment less tripod plus Meade drive corrector, three 2-inch eyepieces, 12mm illuminated reticle eyepiece. $4000 firm, will deliver within 250 mile radius. Contact John Gilkison, Rt. 1, Box 744, Denton, TX 76266. Phone (817) 387-8357.

FOR SALE —Complete sets of Stonyhurst Disks (0° through ±7°) printed on heavy stock. $6.00 per set, includes postage. Contact John T. Goodwin, 376 Weston St., Waltham, MA 02154.

ANNOUNCEMENT — Are you an armchair or observational astronomer? No matter, we have both in the Plutonian Society. Fun with others who share your interest. Bi-monthly newsletter. We're unique! Contact Richard Jepeal, Editor, 3 Short St., New Britain, CT 06051.

ANNOUNCEMENT — ''25 Years of Space Exploration,'' a traveling exhibit celebrating NASA's 25 years in space. Also, a silver anniversary planetarium program, ''Sun Cans, Space Junk, and Silver.'' Contact the Charles Hayden Planetarium, Boston Museum of Science, Science Park, Boston, MA 02144-1099. Phone (617) 723-2500.

ANNOUNCEMENT — The Auburn Astronomical Society welcomes persons in east central Alabama interested in astronomy to join us for dark sky observing, interesting programs, and an opportunity to share experiences and enthusiasm. Contact Russell Wigham, 123 Carter St., Auburn, AL 36830.

ANNOUNCEMENT — The Astronomical Society of Kansas City meets on the fourth Saturday of each month. Meetings begin at 7:30 p.m. in room 103 of Haag Hall Annex at the UMKC campus. The annex is located between Rockhill Road and Holmes on 52nd Street. For information contact the A.S.K.C., P.O. Box 400, Blue Springs, MO 64015. Or phone Gary Pittman, (816) 229-2677.

ANNOUNCEMENT — The Raleigh Astronomy Club welcomes new members and visitors during meetings, held the second and fourth Friday of each month at 7:30 p.m. in Hunter Hall, Meredith College. Programs consist of scientific lectures, films, and observing sessions. Contact R.A.C., P.O. Box 10643, Raleigh, NC 27605, or phone Ward at (919) 787-5095.

ANNOUNCMENT — The first seminar in Electronics Oriented Astronomy will be held at Cypress College on March 3, 1984. Participation is invited in the areas of computers, low-light TV, photometry, digital controls, etc. A book of proceedings is planned. For more info, send SASE to Orange County Astronomers, 2215 Martha Ave., Orange, CA 92667.

ANNOUNCEMENT — The East Texas State University Science Fact-Science Fiction Society will host their second annual Space Awareness Day on the campus of E.T.S.U. on April 24, 1984, from 1:00 p.m. to 11:00 p.m. in the student center. There will be NASA films, a NASA guest speaker from Houston, and two science fiction films. There will also be a souvenir display room and a gaming room. The cost is only $3 for everything. For more information, call Dr. Jack Lamb at (214) 886-5957 or (214) 886-2801.

ANNOUNCEMENT — The Plutonian Society, ''Exploring the Solar System and Beyond,'' which has members in five countries, is seeking new members. If you like to read and write about astronomy and enjoy correspondence, the PLS is for you. Contact Gary Anderson, 8191 Woodland Shore #12, Brighton, MI 48116.

ANNOUNCEMENT — The Rittenhouse Astronomical Society invites you to our meetings held the first Friday of each month at 7:30 p.m. (October through May) in the research laboratory building of the Franklin Institute at 20th and Race Sts. Lectures and field trips. Contact the Rittenhouse Astronomical Society, P.O. Box 12-531, Philadelphia, PA 19151. Or phone Milt Friedman at (215) 885-3466.

ANNOUNCEMENT — The Earth and Space Astronomy Club (E.S.A.C.), a nationwide organization of amateur and professional astronomers, would appreciate any fellow astronomers who would wish to join forces with us and exchange observations of solar system and Messier objects. Eventually we hope to have enough observers around the world so that we will have continuous coverage of activities in the skies. Contact Billy Casebeer, President E.S.A.C., P.O. Box 372, Oologah, OK 74053.

CELESTRON SUPER 8
Byers Worm Gear Drive • Certified Optics

MEADE REFLECTORS & CASSEGRAINS
Long Exposure Drive Systems

BAUSCH & LOMB "CRITERION"
4000, 6000, and 8000 Series

TELEVUE EYEPIECES
Plössls • Naglers • Wide Fields

DAYSTAR H-ALPHA SOLAR FILTERS

COULTER ODYSSEY
Dobsonian Telescopes

Edwin Hirsch
168 Lakeview Dr. RR 2
Tomkins Cove, N.Y. 10986
(914) 786-3738

Demonstrations
in my
Observatory

SALES AND SERVICE

TEXAS NAUTICAL
REPAIR CO.

PRODUCTS BY BAUSCH AND LOMB, BUSHNELL, CELESTRON, EDMUND, FUJINON, LEITZ, MEADE, NIKON, ORION, SWIFT, TELE VUE, AND ZEISS

3209 MILAM
HOUSTON, TEXAS 77006
(713) 529-3551

ADVERTISER LISTING

ADVERTISER	PAGE
Ad-Libs Astronomics	40
Astro Cards	73
Astronomy Island	72
Bushnell	30
Celestron Int.	50,57,61,88
Coulter Optical	58
Enslow Pub.	41
Hirsch, Edwin	65
Jim's Mobile Ind.	72
Lumicon	27,63
MacMillan Pub.	25
Meade Instruments	2-3
Meteorites	74
New England Astro. Optics	72
Orion	23
Optron	74
Photos Unlimited	73
Quasar Optics	72
Sciencia, Inc.	73
Star Products	55,59
Star Tracker	73
TeleVue	63
Texas Nautical	65,74
Tomlin Industries	74
Tuthill, Roger	34,73
Wack Electronics	65

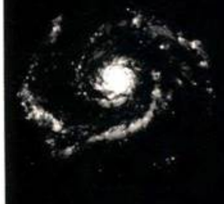
Wear *Challenger's* 'Night Flight' Emblem from STS 8

The Space Shuttle *Challenger's* third flight is depicted on this multi-colored embroidered emblem. NASA's official design features the main fuel tank and solid rocket boosters propelling the *Challenger* into space after the first night launch of a Space Shuttle. STS8's crew included Guion S. Bluford, America's first Black astronaut.

Great to wear on your jacket or cap!

STS 8 4" $4.95

To order, use the AstroMedia order form bound into this magazine, or send to AstroMedia Order Dept., P.O. Box 92788, Milwaukee, WI 53202.



The Midwest's Largest Optical Selection

CELESTRON — complete inventory
UNITRON — complete inventory
EDMUNDS — Astroscan
QUESTAR — 3.5" in stock
MEADE — complete inventory
BINOCULARS — Bushnell, B&L, Pentax, Swift, Celestron
MONSTER BINOCULARS — to 30 x 80

WACK ELECTRONICS
5722 W. North Ave., Milwaukee, WI 53208 (414) 442-3441

POSSIBLE PLANETS

PART I

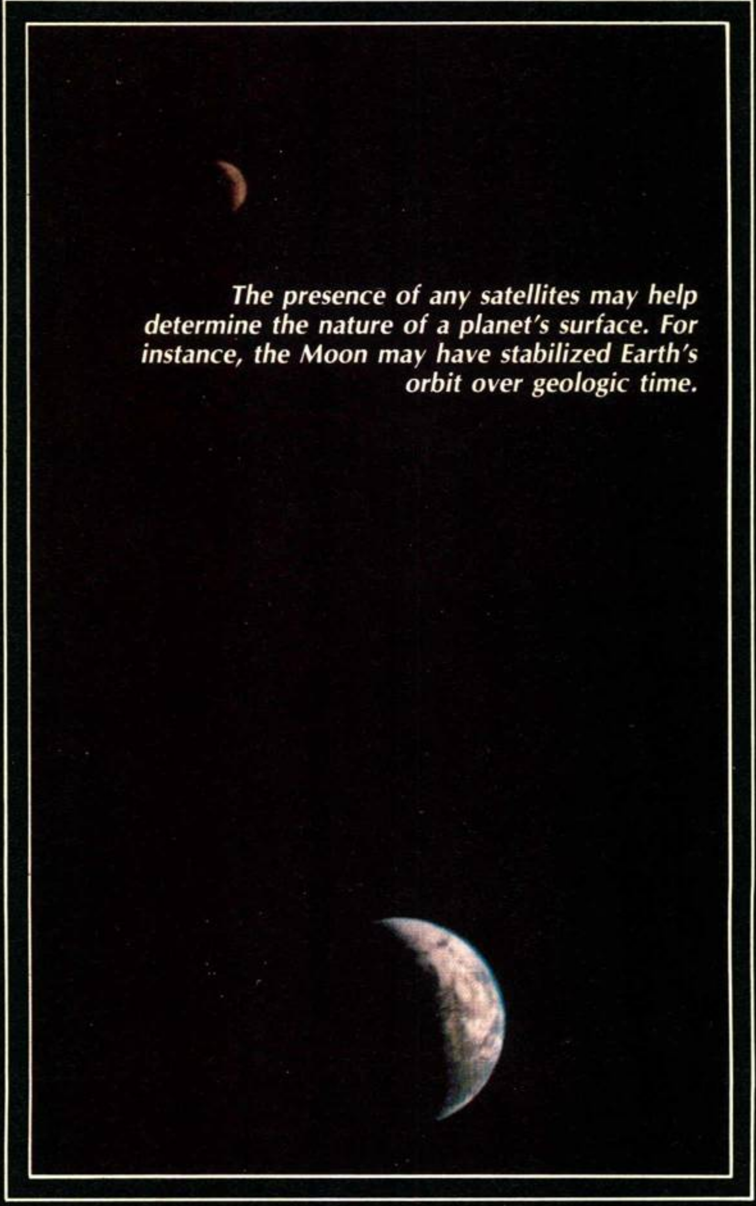
BY
STEPHEN L. GILLETT

Formaldehyde blizzards rage through a carbon monoxide atmosphere. . .

Or a sullen red sun dully illuminates a frigid ammonia ocean, in which strange creatures swim. . . .

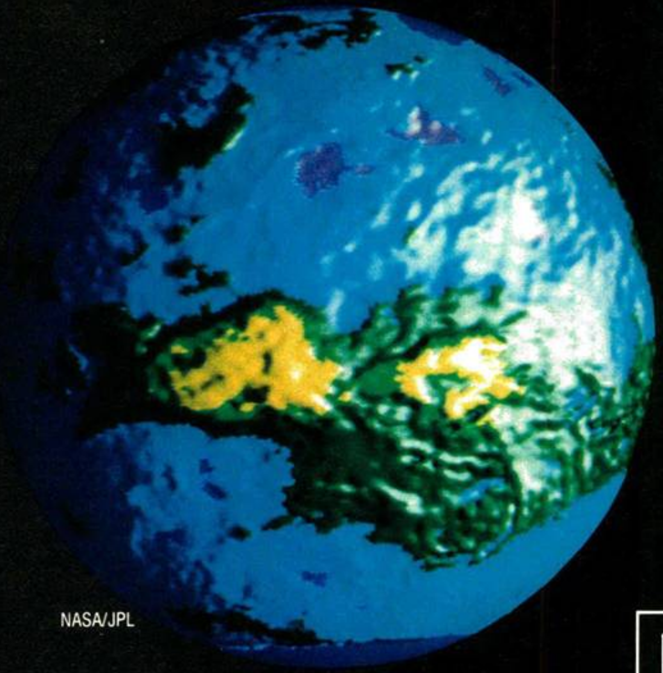
Designing planets is an old pastime of science-fiction writers, but they aren't the only ones who do it — just look at the scientific speculations about conditions on the other planets which have been published in the technical literature of decades past. We were told about Earthlike planets with no sea, or all seas, with thin air, or air too thick to breathe. Barren moons, poisonous atmospheres, double suns, multiple moons, and chlorine-breathing creatures born in ammonia oceans — the speculation was almost unlimited.

After two and a half decades of space exploration, we now know the prevailing conditions on the Moon, Venus, Mars, Mercury, and even the satellites of Jupiter and Saturn. From spaceprobe data, Earth-based studies, and the revolution in geology that has led to a better understanding of the Earth itself, we now have a much better idea of the factors that determine



The presence of any satellites may help determine the nature of a planet's surface. For instance, the Moon may have stabilized Earth's orbit over geologic time.

JPL/NASA



NASA/JPL

The least volatile, most strongly bonded hydrogen bearing compound is water. Still, it's a pretty rare substance in the solar system. Radar maps of Venus (left) reveal large basins that may once have held oceans. Ancient floods have cut deep channels into the martian surface (facing page) suggesting wetter times in that planet's past. The smooth appearance of Europa (below) may be the result of re-surfacing from a watery interior kept liquid by tidal flexing. But Earth (bottom) is alone in the solar system, a world where water in all its phases — solid, liquid, gaseous — exists in plenty.

NASA/JPL

EROS Data Center

NASA/JPL

the nature of a planet. Furthermore, many scientists believe that planetary formation is a relatively common by-product of star formation. Presumably, planets orbit cool red stars, hot blue stars, binary stars, and everything in between. What might these alien worlds be like?

First of all, we'll limit our discussion to comparatively dense planets with solid surfaces and ignore gas giants like Jupiter and Saturn. And we'll only consider bodies that are at least the size of Europa, the smallest of Jupiter's Galilean satellites, and about 3,000 kilometers in diameter. After all, we want bodies large enough to be interesting.

As observers used to a planetary surface, we are most interested in "skin-deep phenomena": the planet's atmosphere and weather, as well as geologic processes that rework the crust, building mountains and volcanos. The interiors of two planets may closely resemble each other — the core and mantle of Venus may be similar to those of Earth, for example — but for us, the differences at the surface are what matter.

So what qualities determine the nature of a world? There are several obvious interrelated factors. First is the planet's size, both its total mass and its radius. Together, these two determine the planet's density, surface gravity, and escape velocity — the minimum speed an object must attain in order to continue moving away from the planet. The escape velocity helps determine whether a planet can retain an atmosphere. Surface gravity affects processes like erosion. The radius also fixes the planet's surface-to-volume ratio, which determines how efficiently it loses its internal heat. The heat of a planetary interior keeps its surface active, driving processes like plate tectonics and volcanism.

Energy received from the Sun (or suns) is another critical factor that influences conditions at the surface. A planet's ability to hold onto its atmosphere depends on its temperature as well as its gravity — gas molecules move faster at higher temperature, and atmospheric material freezes out in an extremely cold environment. Is the surface temperature so high that it completely drives off substances with low melting and boiling points, like water? Do these "volatiles" remain in a hot, dense Venus-like atmosphere? Or do they freeze out to form a global coating of ice, as on Jupiter's outer Galilean satellies? Are conditions stable enough to sustain some volatiles in a liquid phase? While water can slosh about freely on the Earth's surface, other worlds may have seas formed from more exotic substances, such as ammonia or sulfur dioxide.

Next, what's the planet made of? A planet's composition is largely controlled by the abundance of elements in the cloud from which it formed. Hydrogen makes up over 93 percent of the material in the universe, and most of the remainder is helium. Everything else together — oxygen, calcium, iron, uranium, iodine, whatever — amounts to little more than one atom in a thousand.

The heavy elements — all those more massive than helium — were forged in the furnaces of gigantic stellar explosions, or supernovae. Oxygen, carbon, nitrogen, and neon are the most abundant heavy elements because they have exceptionally stable nuclei. Nuclei in the vicinity of iron form the peak of the binding energy curve. That is, you can't get energy either from splitting them (fission) or fusing them. Beyond iron, a nucleus requires energy to form; nuclei heavier than iron are proportionately much rarer than less massive nuclei.

The mechanisms by which a planet formed also influence its composition. Scientists believe that the planets accreted in the nebula from which the Sun formed. The first step toward a planet seems to be the condensation of chemical droplets out of the nebula. Near a growing Sun, the only compounds that could condense were those with high melting and boiling points — the "refractories" like silica or alumina — whereas the volatile substances could only condense farther out where conditions were colder. Eventually, these droplets accreted into planetesimals, bodies a few meters to tens of kilometers in diameter. Finally, the planetesimals coalesced by collision.

This scenario explains the general layout of our solar system: a group of rocky planets near the central star — Mercury, Venus, Earth-Moon, and Mars — a big gap containing some debris (the asteroids) and then the hydrogen-rich gas giants and their moons. The density of Mercury, nearest the Sun, suggests that it is rich in refractory silicates and iron. On the other hand, the densities of Ganymede and Callisto, the two Mercury-sized satellites of Jupiter, indicate that ice makes up about 50 percent of their composition.

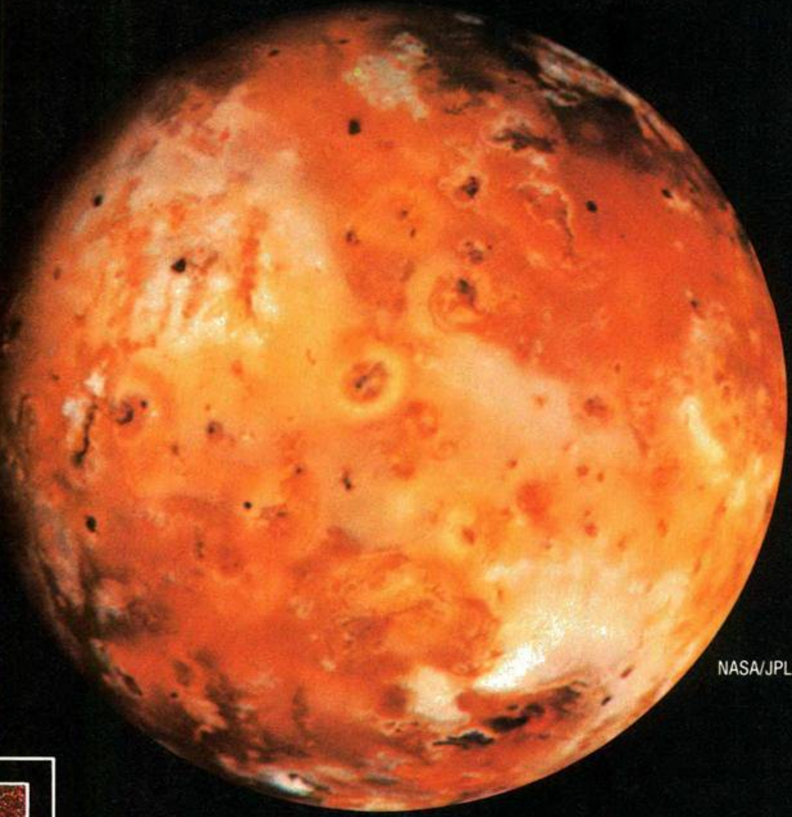
Chemical properties are extremely important in these processes. Considering Earth as a whole, our planet contains little hydrogen and almost no helium, even though those elements make up most of the universe. Hydrogen forms volatile compounds, and helium forms no compounds at all. For the most part, both gases were boiled out of the inner solar system where the Earth formed. Another example: Neon, one of the most abundant heavy elements, is exceedingly rare on Earth, even though our planet's gravity would easily have retained it. But neon forms no chemical compounds, and was driven out.

Astrophysicists still dispute the exact mechanisms of accretion — if other natural phenomena are any guide, they're no doubt quite complicated. Computer simulations suggest that the coalescence of planetesimals to become the inner planets was a largely random process. The size, distribution, and, to some degree, composition of the planets was a cosmic crapshoot.

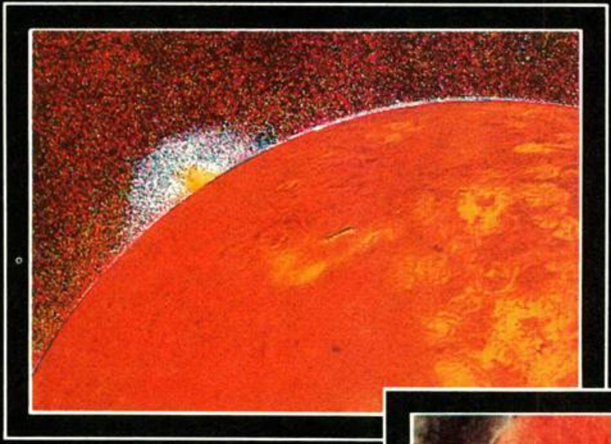
As another example of possible variation, consider the origin of volatiles on Earth. Were they outgassed from the young planet? If so, the gases must have reflected the chemical environment of the crustal rocks in which they formed. Alternatively, perhaps the volatiles arrived in icy comet-like bodies impacting in the heavy bombardment that left the record of gigantic impacts on the Moon and other inner planets. In this case, volatile substances would be chemically unrelated to the rest of the planet — such bodies would represent a sample of material that condensed farther out in the nebula where conditions were very different. Furthermore, sheer chance might determine an inner planet's complement of volatiles. Earth's atmosphere and oceans together, for example, represent only 0.03 percent of its mass. Since the volatiles make up such a small part of a planet's whole, it's easier to change their proportions than to alter those of the major elements that constitute the solid planet.

The surface composition of a planet is further influenced after its formation by chemical fractionation, the processes that separate substances according to their chemical and physical properties. The ferocious volcanism of Jupiter's moon, Io, for

Thanks to planetary exploration, we now know that vulcanism, one of the most violent geological processes, reworks the surfaces of worlds other than Earth. Some of the largest volcanoes in the solar system lie along the Tharsis Ridge of Mars (facing page). The Voyager spacecraft revealed the sulfurous face of Jupiter's moon Io (right) and actually caught volcanic eruptions in the act (below). This intense activity has boiled away everything more volatile than sulfur compounds. On Earth (bottom) volcanoes inject ash high into the atmosphere, perhaps producing subtle climatic effects.

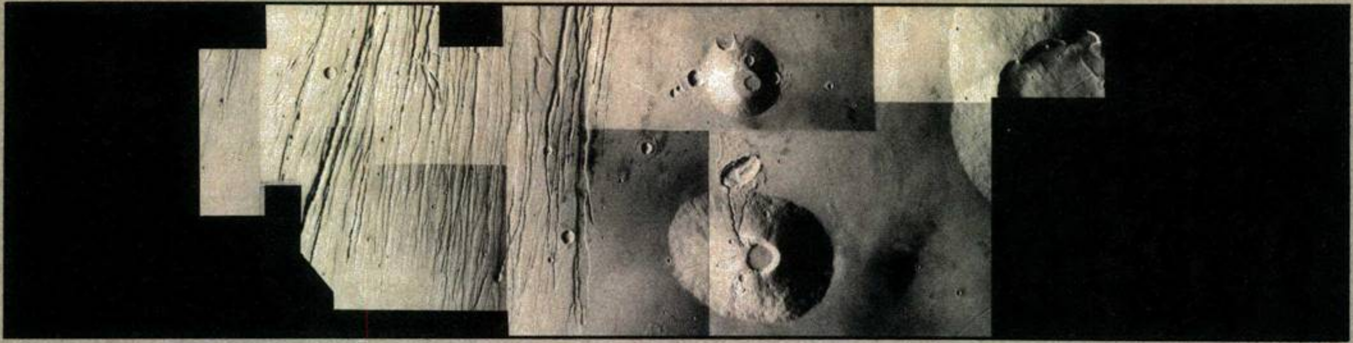


NASA/JPL



NASA/JPL

EROS Data Center



NASA/JPL

example, seems to have boiled away everything more volatile than sulfur compounds, leaving behind a surface dominated by these compounds.

For another example, look at nickel. It's an uncommon element in the Earth's crust — in fact, it's a strategic metal. However, nickel is a rather common heavy element in the solar system, as well as in the Earth *as a whole*. Virtually all of Earth's nickel resides in its nickel-iron core — less than one atom in a hundred remains in the crust. Many other important and familiar elements — copper, sulfur, zinc, gold — are also "depleted" in the crust. By and large, they have stayed inside the Earth. Elements such as chlorine, fluorine, sodium, potassium, titanium, and aluminum, on the other hand, are much more common in the crust than they are in the planet as a whole. Because of their chemical behavior, Earth's interior has "sweated out" these elements. In fact, potassium and titanium don't make the top of the cosmic abundance list, but in the terrestrial crust these metals rank as the seventh and ninth most abundant elements, respectively.

An atmosphere also reacts profoundly with a planetary surface, whether it was outgassed or "plastered on" by collisions with icy bodies. If oceans condense out of the atmosphere, they rework the surface both physically and chemically. On Earth, for example, oceans caused carbon dioxide to precipitate as carbonates in limestone. On Venus, by contrast, the CO_2 stayed in the atmosphere, perhaps because the planet never cooled enough for rain.

Other effects, such as those from a planet's rotation on its axis, orbital motion, or interactions with any satellites, must also be considered. Satellites are more than decorative. They cause tidal braking, slowing down their companion's rotation by raising tides. Tides cause the whole planet to bulge, and the planet's rotation carries the bulge forward. As the satellite pulls back on the bulge, it slows the planet's rotation. Earth's rotation has slowed substantially over geologic time because of the Moon's presence. Our more massive world, of course, has had its own effect — long ago, the Moon's rotation slowed so that its "day" now equals the time it takes to revolve around Earth, with the result that the Moon keeps the same face toward us. For the same reason, the Galilean satellites keep the same hemisphere toward Jupiter.

If the planet orbits close enough, the parent star also causes tidal braking. Due to solar braking, Mercury's rotation is now locked in a stable 3:2 resonance — it rotates on its axis three times for every two orbits about the Sun. Mercury orbits in a more eccentric ellipse than any planet save Pluto. Weird effects result from the combination of slow rotation and orbital eccentricity. At some places on Mercury, for instance, the Sun can rise, reverse direction and set, and then rise again!

Rotation has almost halted on Venus. That planet rotates in a "retrograde" sense — clockwise as viewed from above its north pole. All other planets spin counterclockwise, and all planets, Venus included, revolve counterclockwise about the Sun. The rotation period of Venus is 243 Earth days, but its revolution period about the Sun is 225 days. The planet's "day" is longer than its year!

Orbital arrangements also cause seasons. Our seasons are due to the tilt of the Earth's axis with respect to the plane of its orbit. Uranus has the most extreme seasonal arrangement of all the planets in the solar system. Its rotational axis is inclined 98°, as opposed to Earth's modest 23.5° — Uranus' rotational axis lies almost in its orbital plane! The Sun never sets during the uranian summer, but circles in the sky overhead; conversely, the Sun never rises on that planet during a uranian midwinter. Only during spring and fall, around the vernal and autumnal equinoxes, does the Sun rise and set as we're used to on Earth.

Closer study reveals more subtle dynamic effects. Mars apparently undergoes major, cyclic fluctuations in its axial tilt and orbital eccentricity due to gravitational perturbations from the other planets. Indeed, the Moon may have stabilized Earth's orbit over geologic time, possibly aiding the evolution of life. Even so, small cyclic variations in the Earth's orbital elements — the Milankovic variations — probably help trigger ice ages by slightly reducing the average amount of heat received from the Sun. And volcanic Io, Jupiter's moon, has demonstrated the importance of internal heating by the tidal action between a planet and several satellites.

Finally, a less obvious factor, brought home by solar system exploration: the flux of ultraviolet light. Energetic ultraviolet radiation splits up hydrogen-bearing molecules — a process called *photodissociation*. Hydrogen, the lightest atom, moves fastest at a given temperature and thus escapes a planet's atmosphere most readily. Photodissociation leads to planets rich in heavier gases like oxygen — one way of lowering the high abundance of hydrogen in the universe.

Water has survived on Earth because it is the least volatile and most strongly bonded of the common hydrogen-bearing compounds. Methane and ammonia, other compounds that contain hydrogen, are broken up more easily than water, and the temperature must be a good deal colder than any temperatures available on Earth to freeze them out of the atmosphere. Until recently, you could read it presented as fact that Earth had a primitive atmosphere composed of ammonia and methane. In fact, there's no geologic evidence for such an atmosphere, and photodissociation would have destroyed it in short order.

The "cold trap" in Earth's upper atmosphere was instrumental in water's continuing presence on our world. Water freezes out high in the atmosphere, and only a very small amount gets high enough to be destroyed by ultraviolet radiation. Earth's layer of ozone also acts as a screen that helps keep out molecule-destroying ultraviolet light. Venus has lost nearly all of its water, and it looks as though most of the water on frigid Mars is gone. And yet, some time ago Mars was a world where mighty floods cut deep channels into the surface.

We've now analyzed the basic factors that determine conditions on a planetary surface — everything from elements that compose it to the presence of a satellite. Next month, we'll alter these parameters and look at some of the strange worlds that may exist somewhere in the Galaxy.

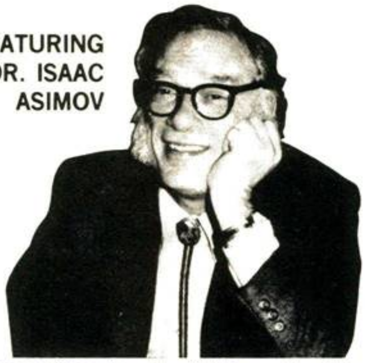
Stephen L. Gillett received his Ph.D. in geology from the State University of New York, Stony Brook, in 1981. His major research interest lies in applying paleomagnetism — the fossil record of Earth's magnetic field — to the solution of geologic problems.

Astronomy Island

Bermuda

11th ANNUAL 7-DAY CRUISE FROM NEW YORK JULY 21 — JULY 28

FEATURING DR. ISAAC ASIMOV



honorary staff member, who will deliver another of his thought-provoking talks. Each participant will also receive a personally autographed copy of one of his books.

THE PROGRAM consists of lectures in astronomy on board our ship as we make the 36-hour sail to Bermuda, and the use of many telescopes at our lovely observing site on the south shore. Our hosts are the wonderful people of the Astronomical Society of Bermuda.

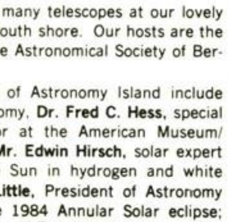
THE STAFF members of Astronomy Island include our Director of Astronomy, **Dr. Fred C. Hess**, special lecturer and instructor at the American Museum/Hayden Planetarium; **Mr. Edwin Hirsch**, solar expert who will show us the Sun in hydrogen and white light; **Mr. Robert T. Little**, President of Astronomy Island, will review the 1984 Annular Solar eclipse; **Mr. Al Nagler**, President of Tele Vue Optics; and **Mr. Craig Small**, Space Shuttle and solar eclipse historian.

THE SKIES OF BERMUDA are unpolluted and grand! Good sense dictated the official banning of neon lights from the islands. Come split your favorite double star!

THE ISLANDS OF BERMUDA are subtropical and famous for their natural and man-made beauty. The charming shops make you feel as though you are in England. No matter what you do, pleasure abounds.

THE M/V ATLANTIC is the brand-new 30,000 ton flagship of Home Lines and docks right on Front street in the capital city of Hamilton, offering international shopping at your doorstep while serving as your plush hotel. All staterooms have private facilities and telephones. Enjoy superb continental cuisine, dance, swim on board, see live entertainment and new movies. Four days of exciting land activities and the round trip cruise make this an unforgettable family vacation.

THE DOOR PRIZE is the stunning new Bausch & Lomb "Criterion 4000" Observatory/Telescope System.



Astronomy Island Ltd. acts in concert with the Astronomical Society of Bermuda. Based on double occupancy, prices begin at about **$1,268**, which includes passage, the above features, membership in the astro society and a chance to win the "Criterion 4000". For further details and a ship's brochure, write to

ASTRONOMY ISLAND LTD. c/o WORLD OF OZ
3 East 54th Street, New York, NY 10022
Tel: (212) 751-3250

CANADA

NEW & USED SCOPES, BINOCULARS
ASTRO FILMS & PROCESSING

CANADIAN DEALER for: BAUSCH & LOMB, BUSHNELL, CELESTRON, COULTER, DAYSTAR, LUMICON, MEADE, SWIFT, TASCO, TELE VUE, WETZLAR, ZEISS

"Compare our selection and price"

QUASAR OPTICS

7719 FLEETWOOD DR. S.E.
CALGARY, ALBERTA T2H OX2
(403) - 255 - 7633

AT LAST!

REMOTE CONTROL FOCUSING

PUT AN END TO THE FOCUSING WIGGLES

30-second installation on Celestron C-8, C-11, & C-14 with two-speed action, electromagnetic braking, and direct drive. No gears or belts to install. Also for Meade Newtonian, Novak Newtonian, and Cass. focusers. Send business size s.a.s.e. for brochure or call.

JIM'S MOBILE INDUSTRIES
1960 Co. Rd. 23
Evergreen, CO 80439
(303) 277-0304

ASTRO MART

FOR SALE — Celestron 11, special coatings, wedge, portable aluminum pedestal, giant focuser, 10x40 and 10x70 finders, 32mm Erfle, 12mm and 16mm Clave Plossl eyepieces, camera attachments. Mint condition. $2950 American, $3450 Canadian. Contact Randy Groundwater, 3400 Askin Ave., Windsor, Ontario, Canada N9E 3J7. Phone (519) 734-6021.

FOR SALE — Quantum 4 in mint condition. Rarely used, $750 plus shipping. Cave 8" RFT with mount, pick up only, $150. Contact Bruce Covey, 251 Miller Lane, Rochester, NY 14617. Phone (716) 266-5198.

FOR SALE — *Sky & Telescope* back issues. 1973 through 1980, three issues missing, in good condition; 1965 through 1969, eight issues missing; some singles. $8 for any complete year, plus postage; $75 for singles. Will negotiate. Contact David Moody, Woodcrest, Rifton, NY 12471.

FOR SALE — Edmund Scientific Astroscan 2001. Primary mirror 4⅛" clear aperture f/4.2, 17½" f.l., parabolic, ⅛ wave, Pyrex aluminized and overcoated. Eyepiece 28mm e.f.l. RKE 45° field, standard 1¼". Accessories: tote bag, rubber base mat, tripod bracket, RKE 15mm, RKE 8mm. $170. Contact Anthony Brown, 3216 Baker St. Apt. C, Berkeley, CA 94702. Phone (415) 655-5126.

FOR SALE — 8" Cave reflector, equatorial mounting with setting circles, clock drive, three oculars. Like new condition, $450. Contact Greg Bruch, 722 N. 13th St. #608, Milwaukee, WI 53233. Phone (414) 272-8636.

NEW ENGLAND ASTRO-OPTICS

Your one-stop source for
QUESTAR - MEADE - TELE VUE - COULTER
free literature
P.O. Box 834
Simsbury, CT 06070
(203) 658-0701
or Source TCU685 MNET 70055,205

TOUR THE MILKY WAY IN BREATHTAKING COLOR WITH THIS SET OF 60 SLIDES

A Color Tour of the Milky Way brings our Galaxy closer than ever — pausing at stars, nebulae, globular clusters, constellations — all in exciting color. The 60 slides were produced and assembled by Ronald E. Royer, a specialist in fine astrophotography whose photographs have appeared in **ASTRONOMY**.

The slide album contains a booklet identifying each image and includes a key to the cameras used, as well as references on tricolor astrophotography.

A COLOR TOUR OF THE MILKY WAY
Set of 60 Slides **$39.95**

To order, use the AstroMedia order form bound into this magazine, or send to AstroMedia Order Dept., P.O. Box 92788, Milwaukee, WI 53202.

ASTRO MART

FOR SALE — Celestron old 7x50 binoculars, $125; RFA with 20mm Erfle, $100; six 0.965" visual filters, $25; five Series V photo filters, $25; Edmund image erector, $40; 15mm RKE, $20; Orion 8x50 RA finder, $55. Contact Gary Kinsman, 10401 Nevada Ave., Chatsworth, CA 91311. Phone (213) 341-4300.

FOR SALE — C-8, special coatings, wedge, tripod, star diagonal, standard Kellner oculars, plus lightweight dewcap, polar alignment adjuster, no tool knobs, piggyback camera mount, Minolta T-adaptor, TeleVue Plossl 17mm and Celestron Erfle 32mm. Spotless condition, $850. Contact Dr. Tom Pekarna, RR2, Le Sueur, MN 56058. Phone (612) 665-6847.

FOR SALE — ASTRONOMY back issues, 1978 through 1982 complete. Sixty issues in mint condition plus two binders, $60. Contact Robert M. Harrison, Rt. 3 Box 199, South Point, OH 45680. Phone (614) 377-9103.

FOR SALE — Dynamax 8, excellent condition, Criterion field tripod, University eyepieces, RFA, nebular filter, and porro prism. Worth over $1200, asking $850. Contact Joe Granito, RD 3, Box 161, Wernersville, PA 19565. Phone (215) 670-0352.

FOR SALE — Variable speed drive corrector, will operate all scopes. 110v AC or 12v DC power. Dynamax dynatracker, $70. Aluminum dew cap for Dynamax 8" or similar telescope, $20. Contact Howard Sherer, 1905 Stirling Dr., Lansdale, PA 19446. Phone (215) 584-0280.

FOR SALE — ASTRONOMY back issues, complete set through September 1980, with miscellaneous 1982 issues. In excellent condition, best offer takes all. Contact Tom Jolly, 100 La Joya, Nipomo, CA 93444.

STAR TRACKER

THE MOST COMPLETE TELESCOPE STORE IN THE KNOWN UNIVERSE

COME IN AND COMPARE

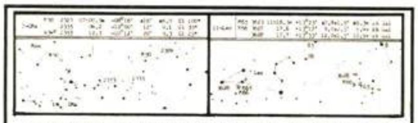
Write for the world's finest telescope Catalog and Reference Manual
$2 U.S.A. $4 Foreign

3093 WALNUT
BOULDER, COLORADO 80302
(303) 442-6805

SPECTACULAR SPACE PHOTOGRAPHS

Photos of Earth, Moon, Apollo, Shuttle
— high quality, free information —

Photos Unlimited
Route 3, Box 225B
New London, NC 28127



INDEX CARD FINDER CHARTS

Made especially for use at the telescope!
75-handy 3x5 star-charts per set.

SET I - THE MESSIER OBJECTS	$7.50
SET II - THE FINEST NGC OBJESTS	$7.50
SET III - THE FINEST DOUBLE STARS	$7.50
SET IV - THE FINEST NGC, Part B	$7.50

2 or more sets, $7.00 ea. 4 or more $6.50 ea.

NEW! OBSERVER'S LOGBOOK

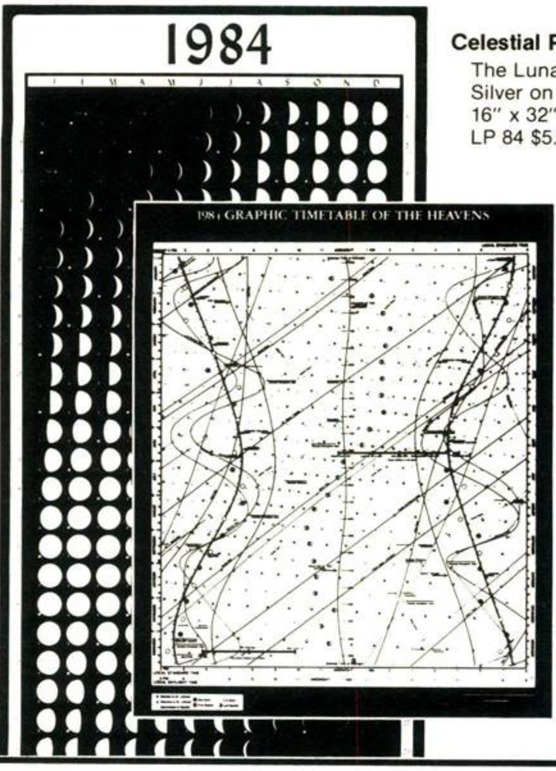
For recording & drawing observations of planets, Sun, comets, deep-sky. 3-ring binder & 100 observing forms. Send for info. $16.95.

Send 37¢ stamp for FREE slide catalog. Outside USA add 20% extra for airmail postage.

ASTRO CARDS
P.O. Box 35, Natrona Heights, PA 15065

SKY GRAPHICS

from Scientia, Inc.



Celestial Products Moon Calendar

The Lunar Phase for Each Day
Silver on Blue
16" x 32" Shipped Rolled
LP 84 $5.00 plus $1.50 shipping

Graphic Timetable of the Heavens

- **Over 10,000 Planetary and Lunar Events Charted**
- **Rising, Transit & Setting Times**
- **Eclipses, Conjunctions & Oppositions**
- **Phases of the Moon & Apogee & Perigee**
- **Six Colors with Blue-Black Border**
- **16" x 20" Shipped Rolled**
- **TT84 $5.00 plus $1.50 shipping**

Order both for $12.00 including shipping

Send check to:

Scientia, Inc.
1815 Landrake Road
Baltimore, MD 21204
Phone (301) 828-5494

8" SOLAR SKREEN AND CELL MOUNTS ON CELESTRON OR MEADE SCOPES

DON'T MISS THE SOLAR ECLIPSE ON MAY 30, 1984. Use our SOLAR SKREEN to SAFELY view or photograph this unique event which will not be repeated in the USA until 1991.

Our famous SOLAR SKREEN (USA Patent #3,897,140) is available in sizes to fit any scope so you can begin to enjoy viewing the fascinating Sunspot activity on our very own star which you have been missing. It uses no glue or magnets & the double aluminum surfaces are shielded from damage. The fine qualities and SAFETY of the SOLAR SKREEN are described in detail by Dr. B.R. Chou in **Astonomy,** March 1982 & **Sky & Tel.,** Aug. 1981.

All SOLAR SKREEN Sun Filters for Celestron 8" or Meade 8" scopes come in a dust free storage container to preserve the fine optical qualtities of this great filter. Inquire about other size filters. All filters carry our Money Back Guarantee.

ROGER W. TUTHILL, INC.
11 Tanglewood Lane, Dept. A14
Mountainside, N.J. 07092
For orders or more information call
TOLL FREE 1-800-223-1063
or fill out COUPON below.
Visa & MasterCard accepted.

ROGER W. TUTHILL, INC.
11 TANGLEWOOD LANE, DEPT. A14
MOUNTAINSIDE, N.J. 07092

YES! Send a SOLAR SKREEN & Cell for my 8" Schmidt/Cass Scope. Here is my check for $75.00 ea. ppd. (N.J. residents add $4.50 sales tax)

NAME

STREET

STATE & ZIP CODE

or bill my credit card:

CARD NUMBER

EXPIRATION DATE

PHONE NUMBER

or Send it C.O.D. (check here ☐)

TEXAS NAUTICAL REPAIR CO.

Authorized Meade Dealer

COME AND SEE THE FINE TELESCOPES AND ACCESSORIES BY MEADE IN OUR SHOWROOM. WE HAVE IT ALL AND OTHER POPULAR MAKES.

3209 MILAM
HOUSTON, TEXAS 77006
(713) 529-3551

Master Card American Express Visa

FREE
FREE
FREE

Free catalog package includes Celestron, Meade and Parks full catalogs and brochures of many other manufacturers, plus discount price lists. The most complete and informative catalog package — yours free. Just write or call.

TOMLIN
INDUSTRIES

679 Easy St., Simi Valley, Calif. 93065 / Phone (805) 522-6646
VISIT THE LARGEST AND MOST COMPLETE TELESCOPE SHOWROOM IN THE U.S.
Open to public Mon. thru Fri. 9-6, Sat. 10-4.

ASTRO MART

WANTED — ASTRONOMY back issues, starting from first issue through 1982, in very good condition. Contact Fuad Wahbeh, P.O. Box 1198, Damascus, Syria.

WANTED — Correspondence with person in the Cocoa, Florida, area to exchange newspaper Shuttle clippings. Contact Martin Attard, 16 Craigielea Ave., St. Albans 3021, Victoria, Australia.

WANTED — Correspondence with anyone, any age, anywhere (Southern Hemisphere preferred) who has made observations with 7x50 binoculars and/or a 3" telescope. I'm interested in double stars and Messier, NGC, and IC objects. Contact Lance Kearns, P.O. Box 1253, Jamestown, CA 95327. Phone (209) 984-3052.

WANTED — UHS tape of first 8 Shuttle missions. Contact Scott Miller, 22382 Raven Way, Grand Terrace, CA 92324. Phone (714) 783-3445.

WANTED — A copy of *U.S. Observatories: A Directory and Travel Guide* by H. Kirby-Smith, published by Van Nostrand-Reinhold (now out of print). Contact Barbara Lebkuecher, P.O. Box 645, Jamesport, NY 11947.

WANTED — I am a high school junior and plan on going into astronomy, especially deep-sky objects and theory. I would appreciate hearing from professionals or amateurs in these fields. Contact Scott Gleason, 302 West 27th, Hutchinson, KS 67501.

WANTED — DEEP SKY, volume 1, number 3 (Summer 1983). Will pay $10 for copy in mint condition. Contact W. Sullivan, 215 N. LaPeer Dr. #4, Beverly Hills, CA 90211. Phone (213) 276-5321.

STS9 Emblem Features First SPACELAB Mission

The Space Shuttle *Columbia* is pictured on this multi-colored embroidered emblem commemorating STS9. NASA's official design shows *Columbia's* payload bay carrying SPACELAB 1, a reusable scientific research laboratory, on the first of many SPACELAB missions. SPACELAB 1 is a joint venture between the European Space Agency (ESA) and NASA.

Great to wear on your jacket or cap!

STS9 4" x 4½" $4.95

To order, use the AstroMedia order form bound into this magazine, or send to: AstroMedia Order Dept., P.O. Box 92788, Milwaukee, WI 53202

YOUNG · SHAW
GARRIOTT · LICHTENBERG
MERBOLD · PARKER
Columbia · Spacelab 1

METEORITES
AVAILABLE TO ASTRONOMERS, SCHOOLS INSTITUTIONS AND PRIVATE COLLECTORS. STONES & IRON SPECIMENS. **LIMITED SUPPLY.**
ROBERT A. HAAG — METEORITES
Box 27527, Tucson, AZ 85726
— PLEASE SEND $1.00 FOR FULL COLOR CATALOG —
Refundable on first order

MEADE
LUMICON
CELESTRON
ACCUTRACK
KALT CORP.
SMITH-VICTOR
STAR ATLASES
TELEVUE OPTICS
DAYSTAR FILTERS
EDMUND SCIENTIFIC
UNIVERSITY OPTICS
SWIFT INSTRUMENTS
ASTRONOMICAL BOOKS
VERNONSCOPE-BRANDON
BUSHNELL OPTICAL CORP.

YOU CANNOT AFFORD TO BUY A CELESTRON
Without Calling Us For The Most Competitive Prices To Be Found Anywhere.
FAST, FRIENDLY SERVICE

FREE PRICE LIST ON REQUEST

Demonstrations by appointment, or call to discuss your specific needs.

OPTRON SYSTEMS
Eugene L. Cisneros
704-706 Charcot Avenue
San Jose, California 95131-2292 USA
Phone: 408-946-4797 daytime
408-923-6800 evening

REVISED, EXPANDED SECOND EDITION

HOW TO BUILD A DOBSONIAN TELESCOPE

Reprints from TELESCOPE Making and ASTRONOMY Magazines

Would you like to build your own 10" telescope? Well, you can — and for a lot less time and money than you thought. Our 52-page booklet gives you complete instructions on how to build a 10" Dobsonian — plus helpful diagrams and plenty of informative articles and photographs on 12", 16" and 20" scopes. This new and expanded edition also tells you how to calculate bearing size, how to use a Poncet platform for deep-sky astrophotography, and how to use setting circles and your pocket computer to find your favorite celestial objects.

This is a complete Dobsonian manual — covering each step from choosing materials to aiming your new scope.

How to Build a
DOBSONIAN
TELESCOPE
Reprints from TELESCOPE MAKING magazine

ONLY $4.95

Also available: TELESCOPE MAKING Magazine —
$10 per year (4 issues)
Add $2 per year outside the USA

To order, use the AstroMedia order form bound into this magazine, or send to AstroMedia Order Dept., P.O. Box 92788, Milwaukee, WI 53202.

prepare for the quadrantids!

by
Terry Schmidt

On the morning of January 4, 1984, the annually recurring Quadrantid meteor shower will do its best to put on a memorable show for observers in the United States. Although that's a time when we usually experience blizzards, clouds, and bitter cold, this year's Quads may produce a shower worth braving the elements to see.

According to Keith Hindley of the British Astronomical Association, the shower has a very short peak of activity — it lasts about 6 to 8 hours — centered on 282.83° solar longitude (epoch 1950). The shower maximum will take place on the morning of the 4th at 6:37 a.m. EST (5:37 CST, 4:37 MST, 3:37 PST); dawn begins at 40° north latitude at 4:45 a.m. local time. This means that peak activity will occur in a bright dawn sky for the eastern part of the country, but in a dark sky for the remainder. The Moon, a mere two days past New, will have set long before.

The narrow maximum, coupled with occasional interference from the Moon, means that the shower can be seen well only once every 8 to 9 years. Bad weather can easily double or triple this, making the Quadrantids one of the most difficult showers to observe. This year, with rates expected to run around 100 to 150 meteors per hour — including many fireballs — a memorable display is likely.

Canadian meteor astronomer Peter Millman lists the shower's radiant as r.a. 15h 28m and dec. +50° (1950 coordinates). But other evidence indicates that instead of one radiant, two very small ones close together may be more likely. If so, a mean radiant for the shower would lie at 15h 28m and +52° 35′ (1950). Using this, we can calculate the elevation of the radiant for different cities across the country at peak activity: New York City, 67°; Chicago, 59°; Denver, 48°; and Los Angeles, 35°. Balancing elevation against dark skies, it appears as though the central and mountain states will have the best views.

Above: A tripod-mounted camera with a 50mm f/1.9 lens and Tri-X film netted Sam Whiten this photograph of a Perseid in August 1980. Although meteor photography doesn't demand much equipment, the low temperatures to be expected for this month's Quadrantid shower call for some special preparations.

What Makes a Meteor?

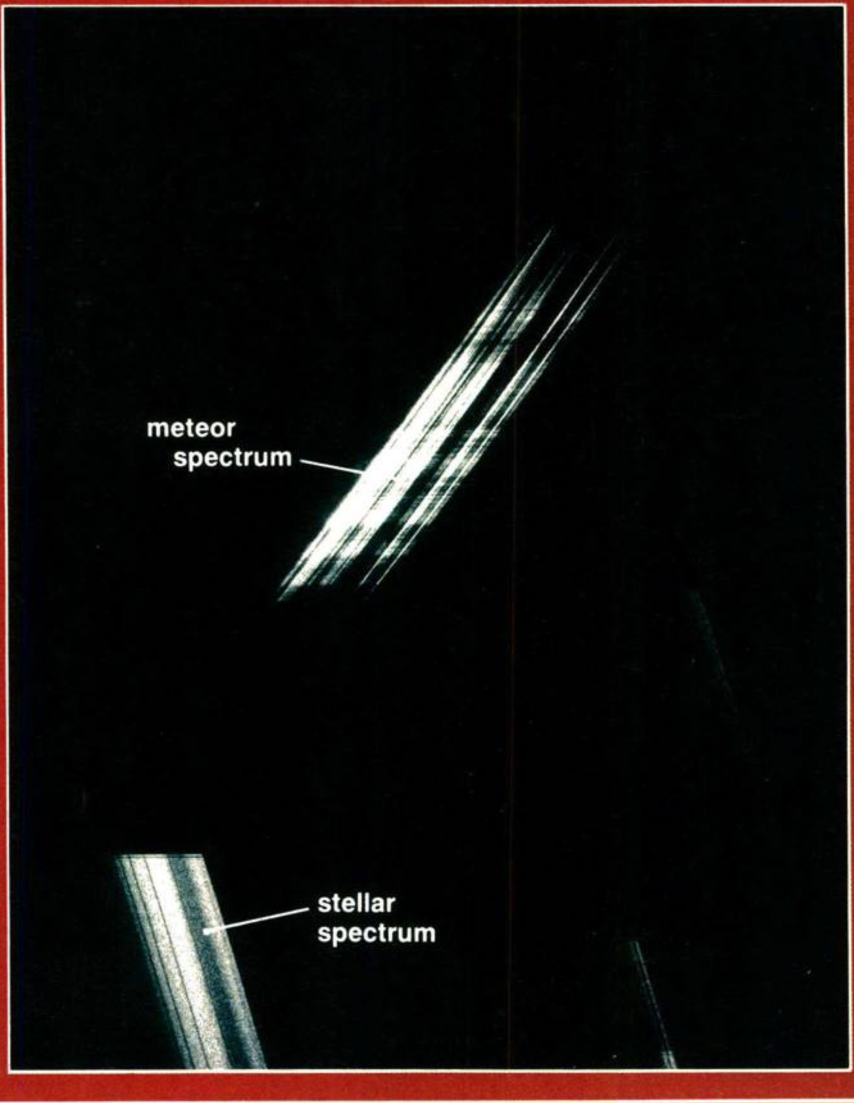
Let's now step back a moment and look at just what we'll be seeing when the Quadrantids put on their display. Meteors originate from comets: The dust driven off the nucleus of a comet first streams out into the tail and then spreads along the comet's orbit. If Earth happens to cross the orbit of the comet, we see a meteor shower.

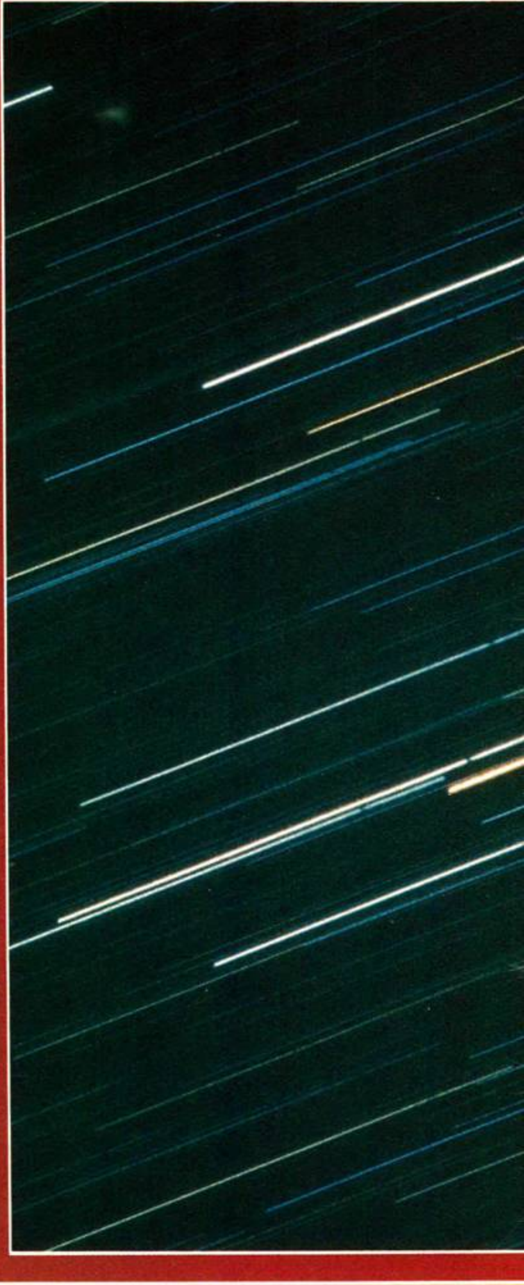
Colliding with our planet at high speed (the Quadrantids travel about 40 kilometers per second), each particle of dust speeds through the rarefied gases in the Earth's upper atmosphere. On its way down, it bumps into more and more air molecules and excites them to glow. As it penetrates deeper into the atmosphere and the air density becomes greater, a bow shock wave of compressed air forms in front of the particle. This shock wave first heats the particle and tears it apart. Then the newly exposed pieces of the particle ionize air molecules over a greater area causing a sudden extra burst of light. Finally slowed to modest speeds, the remnants of the original particle cool off and flicker out.

The luminous phenomenon is called the meteor's *trail*. If a meteor leaves a column of ionized gas in the wake of its passage, it is known as a meteor *train*. Trains can persist for remarkably long times — up to several minutes in extreme cases.

As mentioned before, a meteor shower appears to come from a point in the sky, known as the radiant. Radiants are determined by tracking the streaks of the meteors and plotting them accurately on a star map. You extend their paths backward and note where they converge. (The paths of some meteors won't form a

Below: Though it records only the brightest meteors, spectrographic photography can produce interesting results. This photo, taken in 1982 of a −2.5 magnitude Geminid, shows a spectrum dominated by emission lines of iron. Tiara Observatory photograph. Right: A +0.5 magnitude member of the southern Delta Aquarid shower, recorded during a half-hour exposure. Tiara Observatory photograph.





radiant — such random objects are called "sporadics.") The constellation that plays host to each radiant, by tradition, lends its name to the shower. Thus we have such noteworthy examples as the Perseids, the Orionids, and the Geminids.

But what of the Quadrantids? In 1795, French astronomer Joseph de Lalande created a constellation, Quadrans Muralis — the Mural Quadrant — out of a few stars from Hercules, Bootes, and Draco. Unfortunately, his creation never "took," and the stars of the group have been given back to their original constellations. However, Lalande's Mural Quadrant lasted long enough to bestow its name on this meteor stream — otherwise we might be preparing to observe the "Bootids," "Herculids," or "Draconids."

A shower's richness is often described by its zenithal hourly rate (ZHR). This somewhat abstract figure is the number of meteors that a keen-sighted single observer would see if he looked up with no Moon, no clouds, a horizon free from obstructions, and with the radiant directly overhead. It clearly represents an ideal that few if any observers actually see. But to place everybody's hourly meteor sighting counts onto a standard system, scientists devised the ZHR as a common denominator for comparing observations.

If you want to convert your observed hourly rate to a ZHR, it involves nothing more than a little trig on a pocket calculator. The formula goes as follows:

$$ZHR = ((60 / T)\ N) / (\sin (A + 6°))$$

where T is the observing time in minutes (one hour is customary), N is the number of shower members you see in that time (do not include sporadic meteors or meteors from other showers), and A is the angular altitude of the radiant in degrees at the mid-point of each time period.

Preparing to Observe

The first order of business is to find a dark site free from light pollution. City dwellers may have to travel some distance out of town, and even if you live in the suburbs, it's worth making a short expedition to get out beyond most of the city lights. The next priority is to assure that you'll be comfortable (but not *too* comfortable lest you fall asleep) while you observe. Many meteor watchers use reclining lawn chairs, but since icy winds like to bite you from the backside, plan to have plenty of warm padding beneath you. Backpackers' sleeping-pads are an excellent remedy.

For yourself, put on many layers of warm lightweight clothing. But be careful not to cram on so much that the circulation to your extremities is cut off — that would earn you a thorough chilling, at the very least. Gloves, mittens, scarves,

ski caps, parkas — you know what keeps you warmest, so use it. Since you'll be sedentary most of the time, wrap up in a sleeping bag or several layers of blankets. One of those aluminized Mylar "space-age blankets" as the outermost layer is a good idea; it will trap a lot of warmth that would normally escape.

If you wear glasses, buy some anti-fogging cream to apply to the lenses. Trying to clean frost off glasses is very difficult — and besides, you'd probably miss the fireball of a lifetime while doing so! If you wish to write up a logbook, it's best to let another person do it so that you are not distracted from looking at the sky. One simple and popular method is to record your observations with a portable tape recorder. Just make sure that the recorder itself stays warmly buried under your blankets with only the microphone exposed. If the batteries get cold, they will lose power and you'll begin to sound like Donald Duck on the tape.

Whatever log you keep, record the beginning and ending times of your observations and the times the meteors appear. Call out "Quad!" or "Sporadic!" and make an estimate of the meteor's brightness to the nearest half magnitude. A meter- or yard-stick held in your hands to align with the meteor trails will help you identify shower members if you're uncertain. If the meteor traces back to the radiant, you can call it a true shower member.

Putting Your Camera to Work

Photographing the Quadrantids will not be easy. If temperatures fall below freezing — and over most of North America this is likely on January 4th — the possibility of your camera's shutter and winding mechanism seizing and jamming becomes pretty good. If this happens, the camera must be warmed before it will work properly. One way is to place the camera under your blankets until it thaws. A faster method would be to put the camera near the heater vent inside your car.

A heating coil wrapped around your lens will prevent it from frosting over. A coil rated at one to five watts is more than sufficient for the purpose; buy heat tape used for thawing pipes. Be sure to get one that does not have a thermostat wired in — you'll need continuous operation. Failing this, keep a hair dryer handy and play a stream of warm air over the lens from time to time.

There are a few "musts" in meteor photography. First, the camera must be on a stable mount, such as a sturdy tripod. Second, the camera must be able to take time exposures — which rules out most Instamatics. (Look for a "B" or "T" shutter setting.) Another necessity is a locking cable release. The release keeps your hands from vibrating the camera when you trip the shutter. To be extra sure that *no* vibrations from opening and closing the shutter occur, use the black card method. Hold a matte black card just in front of the lens while you press the cable release to start the exposure. Give the vibrations a few seconds to die out, and then flick the card away. To stop the exposure, reverse the procedure.

Set your lens open to its widest f/stop (lowest f/number), and use the fastest film you can get. For black and white photography try Kodak Recording film, which has an ASA of 1000. If you have a 120 roll-film camera, try Royal-X Pan (ASA 1600). If you develop your own film, you can push Royal-X Pan to 16,000 ASA by developing it in Dektol diluted 1:2 with water. Develop it for 10 minutes at 70° F with nearly continuous agitation. (But prepare for "monster" grain!)

Regarding color films, Ektachrome 400 produces good usable slides. Another film worth trying is Ektachrome 160 tungsten. This gives a very good blue sky and good color response to stars and meteors even though it is not a daylight-rated film. For prints, try the new Kodak VR-1000.

When you set the camera up, don't aim it straight at the radiant; any meteors caught that way will have short trails. Instead, point the lens about 45° to 60° away from the radiant. This will maximize your chances of getting a good trail without your aiming where the meteors spread out too thinly across the sky. For exposures, a little trial and error will tell how long you can run before the sky background fogs the film; experience shows that in most cases under a dark sky, half an hour is about tops.

For the adventurous, another route lies open — spectrographic photography. A prism placed in front of the camera lens will break the light of the meteor up into its various colors and will tell something of its composition. A 30° prism is ideal but hard to obtain; a cheaper alternative is to buy one of those replica diffraction gratings that Edmund Scientific sells and place it in front of the lens.

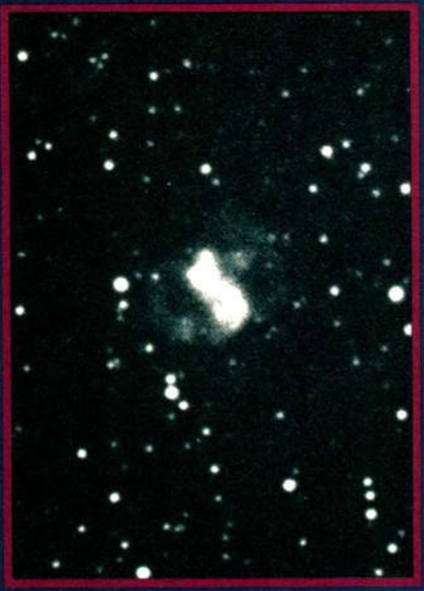
For the spectrum to record, the meteor has to be bright and must travel as nearly parallel as possible to the leading edge of the prism or the grooves in the grating. Thus the prism or grating should be aligned so that meteors coming from the Quads' radiant will travel in the proper direction across the film. And bear in mind that with the extra absorption due to the prism or grating, you'll catch only the brightest meteors.

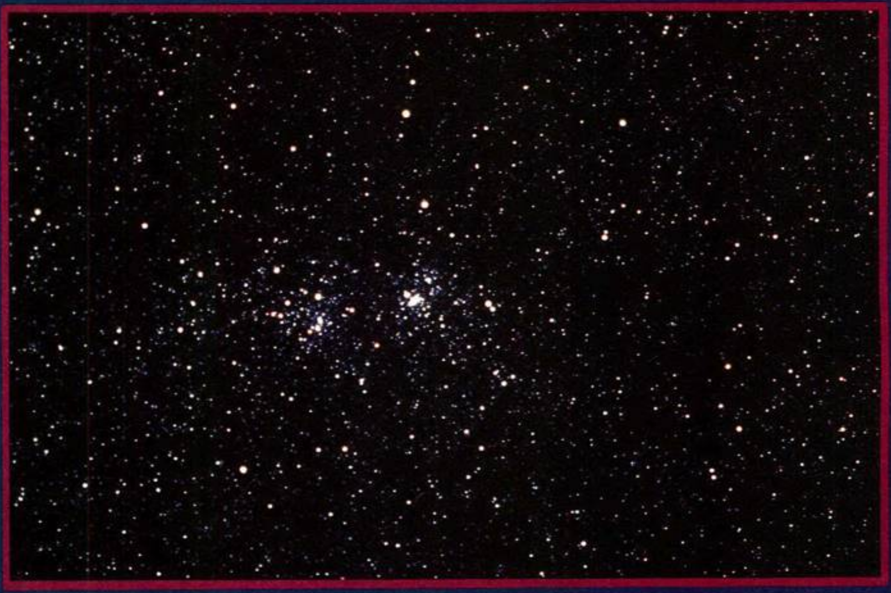
Putting Your Observations to Use

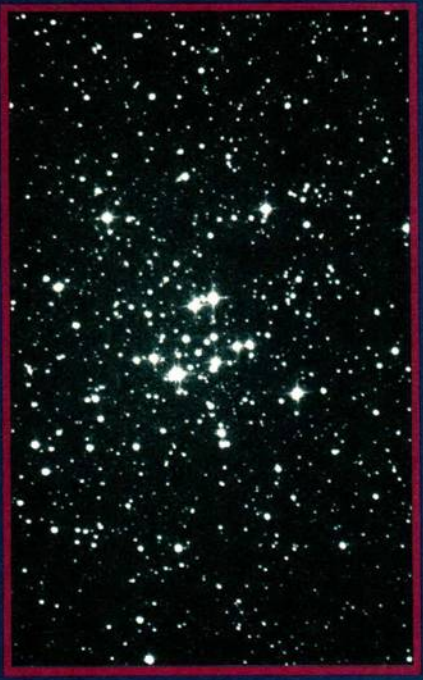
If you wish to contribute your observations to a good source, send them to *Meteor News*, Route 3, Box 424-99, Callahan, Florida 32011. Worthwhile observations will be published in that periodical, and the results will be sent on to the American Meteor Society. Along with your observations, include the following information: longitude and latitude of your observing site, the time used for observations (EST, MST, etc.), the beginning and end of each hour's observation, percentage of sky covered each hour by clouds or horizon obstructions, and the faintest star visible each hour at your zenith (6.5 magnitude, for example). This additional information can turn your logbook from a curiosity into something valuable for scientific research — keep it in mind while you observe.

I viewed my first Quadrantid display in 1970, with the temperature at a brisk −34° F. More recently, the temperature was −42° F during the 1982 display! No matter what it falls to this year, the Quadrantids should put on a good display, and any prepared observer will see a celestial wonder to remember for years to come.

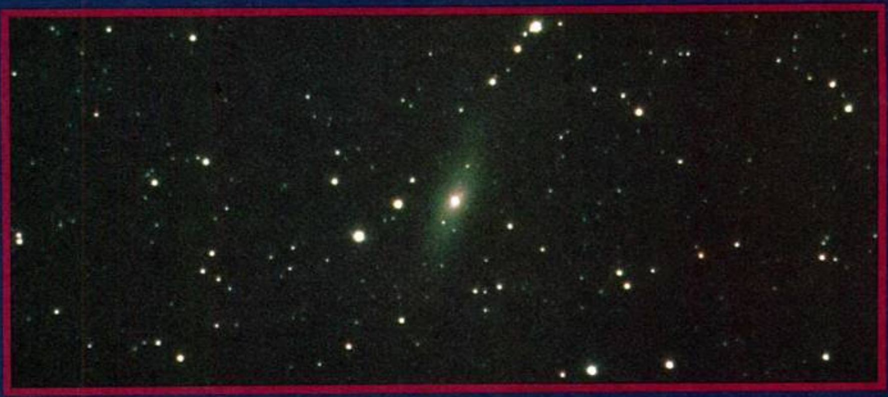
Terry Schmidt has directed the Tiara Observatory in South Park, Colorado since 1969, and has been a member of the Meteoritical Society since 1972. A research astronomer, he also teaches at the University of Colorado in Colorado Springs.

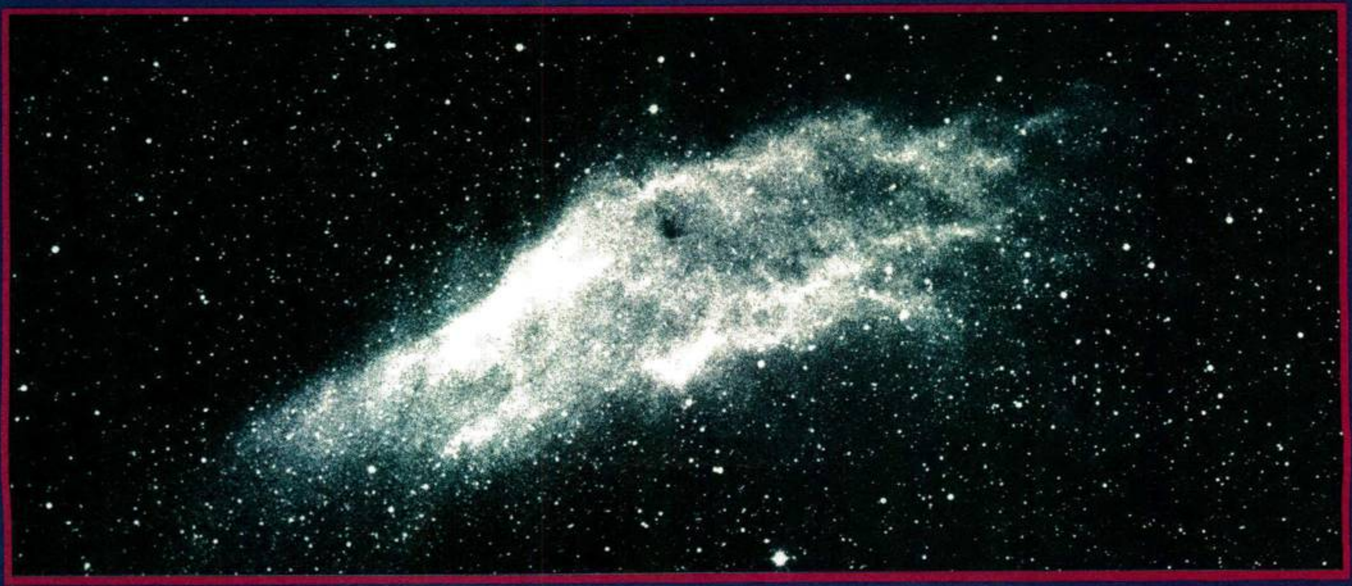






Top left: M-76, the Little Dumbbell Nebula, is one of the faintest and most trying Messier objects to see. Photograph by Martin C. Germano. Top right: Hundreds of blue and white stars cover the field surrounding the Double Cluster; photo by Bill Iburg. Middle right: The 11th magnitude galaxy NGC-1023 shows its bright central hub to 6-inch telescopes on good nights. Jack Newton photograph. Below: One of the most difficult to find of the large emission nebulae, the California Nebula is visible only with superb skies. Photo by David Healy. Middle left: Lee Coombs recorded the stars of M-34, which fill a low-power eyepiece and even offer a good binocular view.

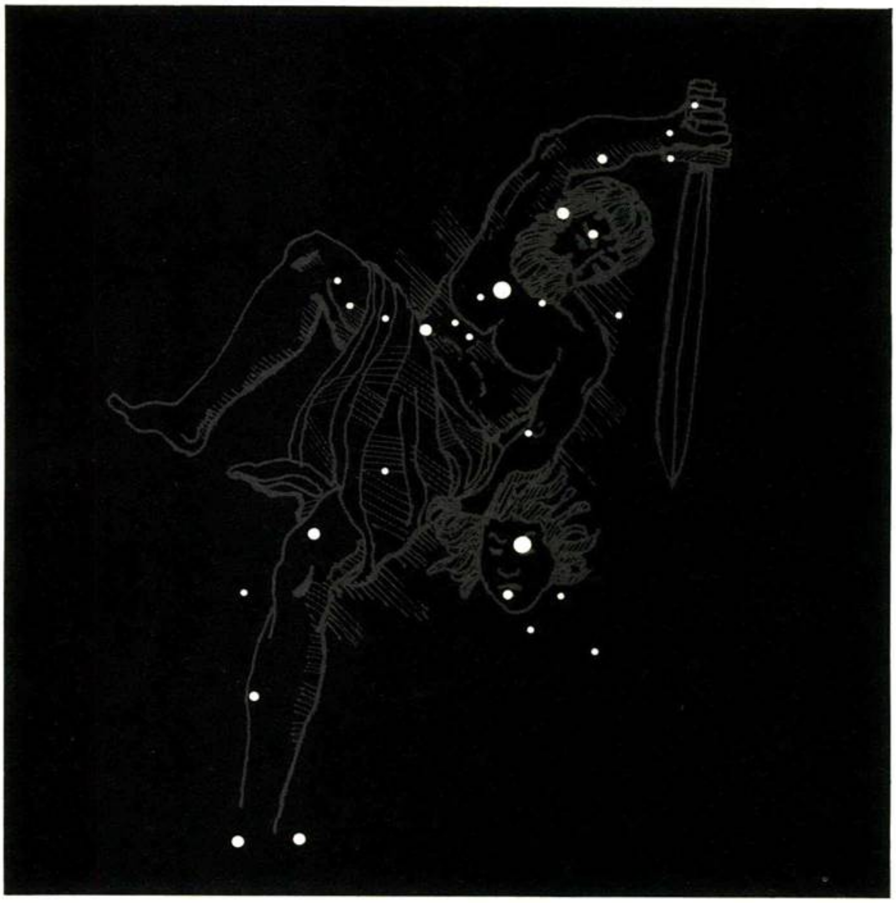




Perseus

Per

Persei



Perseus the Hero is a rich area of sky representing in part our view toward the neighboring Perseus Arm of the Galaxy. It is chock full of bright stars and clusters; flanked by the sparkling Pleiades cluster (M-45) in Taurus and the elusive nebulae IC 1805 and IC 1848 in Cassiopeia; it even contains some rather exotic objects that will tax your telescope's optics and your observing experience.

As you look up toward Perseus, the combined soft glow of the **Double Cluster** (NGC-869 and NGC-884) is sure to catch your attention. So commandingly bright are these two star groups that they warranted the designations "h" (NGC-869) and "χ" (NGC-884) from early celestial cartographers. The two clusters lie side by side half a degree apart, so they require a wide field of view to be seen together — try 30x with a 6-inch or 40x with an 8-inch scope. Both clusters measure 35′ in diameter: NGC-869 is the brighter at magnitude 4.4, while NGC-884 glows at magnitude 4.7. With binoculars or a small telescope, the field of view appears peppered with two areas of bright blue and white stars, the brightest of which are 7th magnitude objects. With an 8-inch scope at 35x, a rich Milky Way field surrounds several hundred bright A- and B-type supergiants. A few dim red stars show up in and around the clusters — these are M-type supergiants.

NGC-884 is more distant than NGC-869, and much older. The former is 11.5 million years old and lies 2.5 kpc distant, while the latter is only 6.4 million years old and 2.15 kpc away. Each is about 70 light-years across and contains around 5,000 solar masses. Since each cluster contains only a few hundred stars, they are truly supermassive and superluminous.

Less than 2° northeast of the Double Cluster is **NGC-957**, a smaller but still impressive open cluster. This is a group of 40 stars of 11th to 15th magnitude packed into an area 10′ across — it is fairly rich and shows up well against the Milky Way background. Use a low power eyepiece for this cluster, increasing the magnification if you wish to inspect the group's core. This cluster lies at a distance of 2.3 kpc, and is apparently physically linked to the Double Cluster.

The largest conglomeration of stars in the constellation is not a true cluster at all, but rather a stellar association called **Perseus OB-3**. This group is roughly centered on Mirfak (Alpha [α] Persei), contains 70 stars between 5th and 10th magnitude, and covers several square degrees of sky. These stars probably constituted an open cluster some 4 million years ago, and have since expanded away from each other while moving through space. The group measures some 300 light-years across and lies 170 parsecs off. If you scan this area with a pair of binoculars, you'll be delighted at the rich groupings of bright blue-white stars.

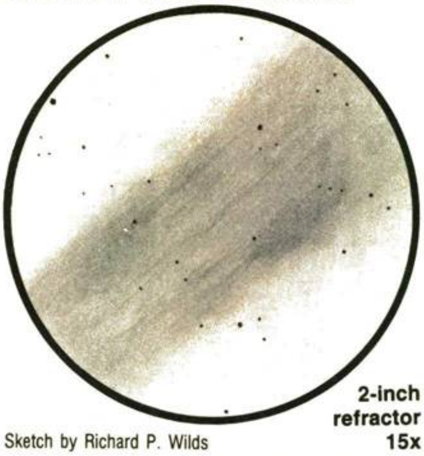
In the midst of the Per OB-3 group is the bright open cluster **NGC-1245**, containing 40 stars fainter than 11th magnitude. Its total magnitude is around 7: In small telescopes it appears as a generally hazy circular group due to the faintness of its members. A 4-incher shows a patch of nebulosity mixed with a few stars; scopes in the 10-inch to 12-inch range reveal a multitude of tiny granular stars across its 10-arcsecond diameter like salt spilt on black velvet.

Another fine open cluster in Perseus is **NGC-1528**, an aggregation of 80 stars fainter than 7th magnitude about 25′ in diameter. This is a bright, obvious group in binoculars, which show it as a mottled grainy haze with several bright stars popping out. It is easy to observe at a total magnitude of 6, and a small telescope shows a fairly rich grouping, many of the fainter stars being arranged in pairs and triplets about the general hazy background.

The finest lone star cluster in this area is the large group **M-34** (NGC-1039). This cluster holds 80 stars fainter than 7th magnitude in an area spanning 20′ across — it is a grand binocular target appearing as a misty spot of stars and nebulosity. A small telescope such as a 4-inch, when used at low power, shows a large, scattered group of bright stars including the doubles OΣ 44 and h1123 near the group's center. With a 6-inch scope the group shows three "arms" of stars radiating outward from its center. This group is just visible with the naked eye under dark skies. It lies around 500 parsecs off, measures 18 light-years across, and, at 100 million years, is much older than either of the Double Cluster components.

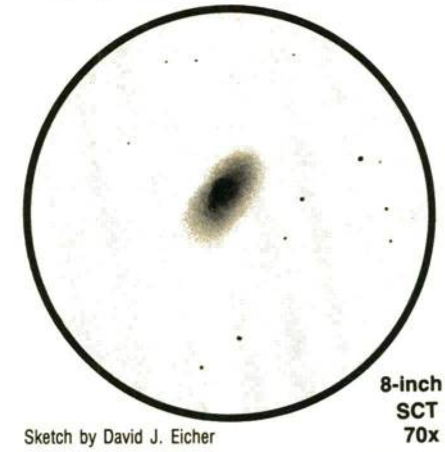
Several unusual stars lie in this area, one of which is **Algol** (Beta [β] Persei), the prototype eclipsing variable star. Regularly as clockwork, Algol undergoes a dimming stage lasting 10 hours once every 2.86739 days. The reason: its whitish B8 primary star is eclipsed by the much fainter G or K-type companion. The system lies 30 parsecs away; the primary measures 2.6 million miles in diameter and the

California Nebula



Sketch by Richard P. Wilds

NGC-1023



Sketch by David J. Eicher

companion some 3 million miles. Thus when the companion's orbit carries it into our line of sight to the primary, it blocks the brighter B8 star and plunges its brightness from magnitude 2.1 to 3.4.

To observe Algol's changes in brightness, go out with a pair of binoculars and make a sketch of the star and its surrounding field. After you do, estimate the brightness of the neighboring stars — especially those close to Algol's brightness — and record them. By comparing stars close in brightness with Algol over a period of several nights, you'll see that this "Demon Star" does indeed regularly fluctuate in brightness.

On February 21, 1901, a 13th magnitude anonymous star in Perseus violently exploded in the century's first nova outburst. The amateur astronomer T.D. Anderson of Edinburgh, Scotland found the 2nd magnitude out-of-place speck of light, and within 2 days **GK Persei** increased its light output sixfold to shine at magnitude 0.2 on February 23. Within three weeks it faded 4 magnitudes, oscillating in brightness in a strange fashion. After another four months the oscillations stopped and the star faded out of sight. Soon thereafter Dr. Max Wolf at Heidelberg discovered a nebula surrounding the star, growing at a fantastic rate of 2" per day! Apparently, however, the star was merely illuminating a dark nebula which already existed. GK Persei lies at a distance of 450 parsecs; it still shows irregular variations in light, which brands it a recurrent nova. It hovers around 13th magnitude, but may rise to 11 or fall to 14 at irregular intervals. Look for the star — who knows *what* you may find.

A fine multiple star is **Zeta (ζ) Persei**, a magnitude 2.8 B1-type star which serves as the keystone to the Zeta Persei group, an association of young stars. This star lies 340 parsecs away and is associated with some nebulosity, which suggests a youthful age. It displays several companions in small telescopes: 12.9" away at position angle 209° lies a 9th magnitude star that has been described as "ashy," the primary being greenish white in color. Some 33" off in p.a. 287° is an 11th magnitude star, and 195" away in p.a. 195° is a 9.5 magnitude companion.

Nearby Xi (ξ) Persei is responsible for illuminating the large elusive **California Nebula** (NGC-1499). At 145'x40', it is one of the largest emission nebulae in the northern sky, but is not nearly as easily observed as the Orion, Lagoon, or even the Rosette Nebula. The brightest parts of this nebula may shine around 14th magnitude; sky darkness and transparency dictate success with the California. In most locations it is invisible in 6-inch, 10-inch, and even 18-inch RFTs, but at a superb site it is observable with binoculars or a 2-inch telescope. A nebula filter seems to help greatly with seeing this object. Be patient; if you do spot the California Nebula, you are among a select group of deep-sky observers.

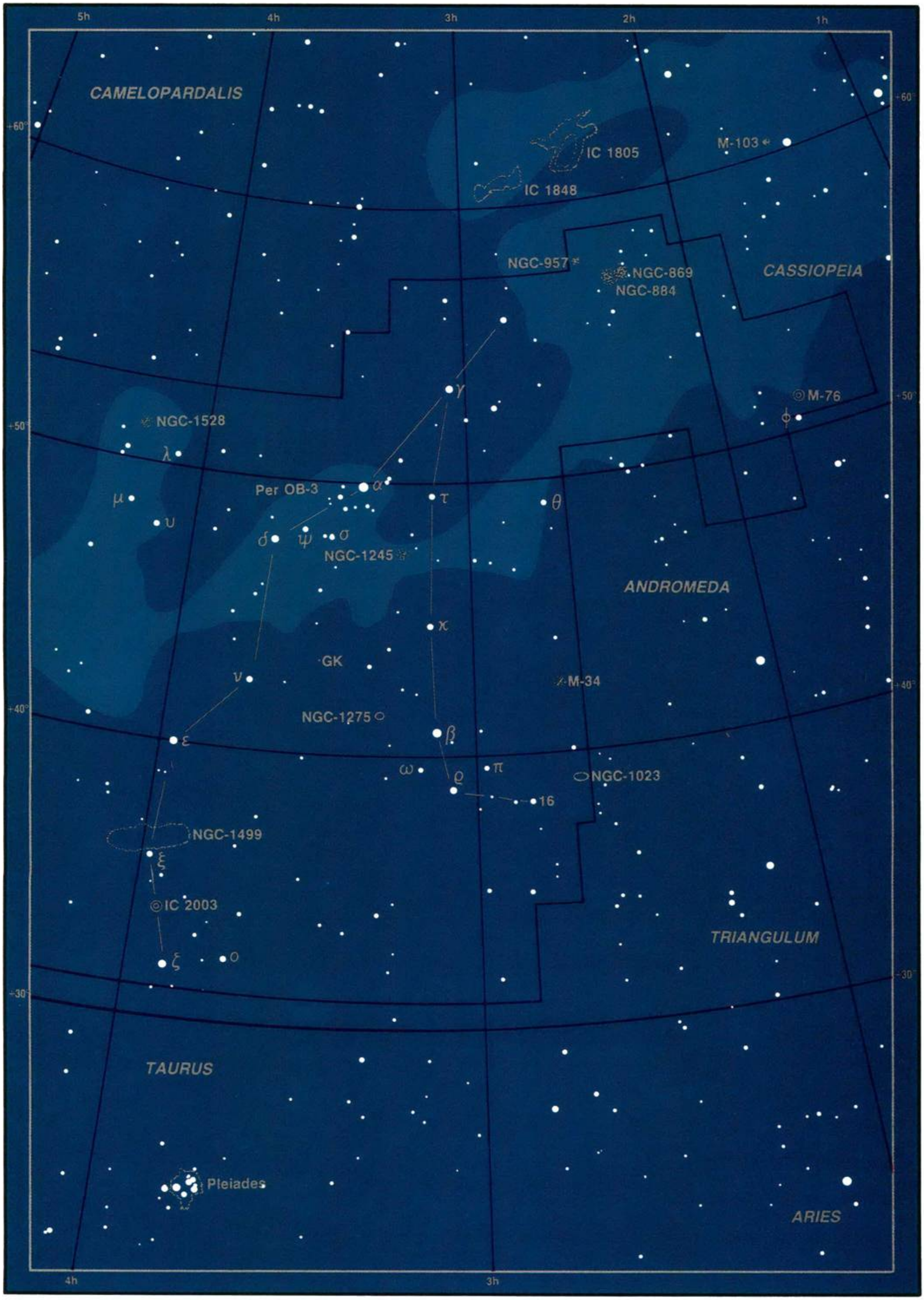
Two fine planetary nebulae lie in Perseus: **M-76** (NGC-650/1), the Little Dumbbell Nebula, is a miniature version of M-27 in Vulpecula. Its twin lobes of nebulosity glow at 11th magnitude, making it one of the finest planetaries in the sky. Train a low-power eyepiece a degree north-northwest of Phi (ϕ) Persei and you'll see the double patch of fuzzy light. If conditions permit, "crank up" the magnification to something like 25x per inch of aperture and you'll get a fine sight. This expanding shell of gas lies about 550 parsecs away and measures, as most planetaries do, about a light-year across. Another planetary in the constellation, **IC 2003**, is a 12th magnitude object only 5" across — compared to M-76's diameter of 140" — and appears stellar under bad seeing. Wait for a good night and search for it with medium power eyepieces.

Two fine galaxies lie within Perseus' boundaries: **NGC-1023** and **NGC-1275**. The former is a bright E7-type lens-shaped galaxy shining at 11th magnitude, and is a fine sight in even 4-inch scopes. It lies in a rich field of stars and shows its bright elongated nucleus and faint outer envelope of nebulosity to any user of a good 6-inch scope. NGC-1275, also known as radio source Perseus A, is a tough target for amateur scopes. This unusual disturbed galaxy, which some astrophysicists speculate may house a supermassive black hole, measures only 42" across and dimly glows at magnitude 13. An 8-inch scope on a good night shows a tiny grainy spot of weak light.

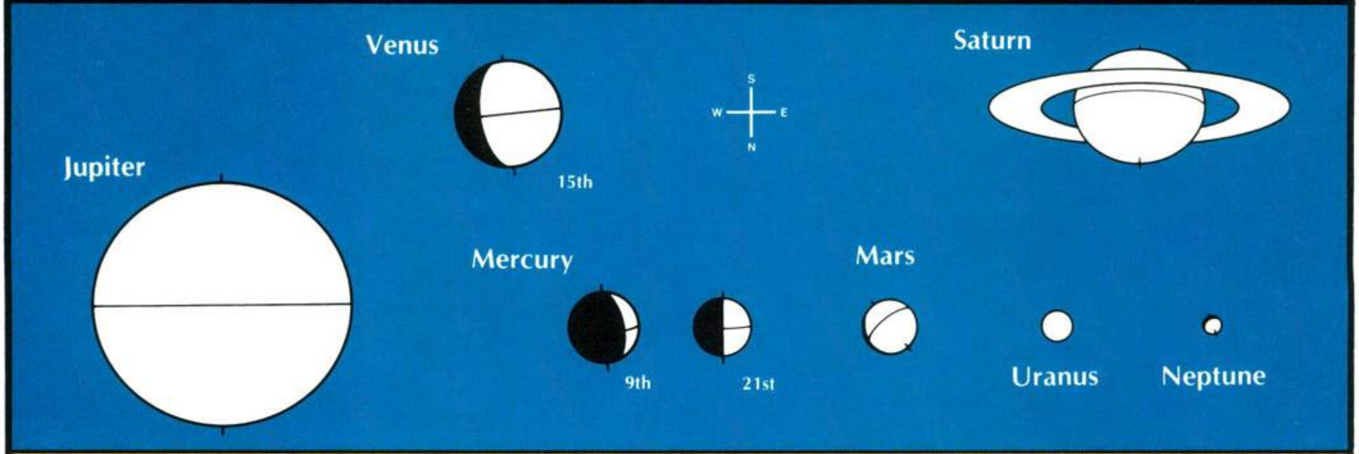
Object	M#	Type	R.A. (2000)	Dec.	Mag.	Size/Sep./Per.	N★	Mag.★
NGC-650/1	M-76	■	01h 41.9m	+51°34′	11.0	140″x70″		16.5
NGC-869		⊙	02h 19.0m	+57°09′	4.4	35′	340	7...
NGC-884		⊙	02h 22.5m	+57°07′	4.7	35′	300	7...
NGC-957		⊙	02h 32.5m	+57°31′	7.2	10′	40	11-15
NGC-1023		0	02h 40.3m	+39°05′	11.0	4.5′x1.3′		
NGC-1039	M-34	⊙	02h 42.0m	+42°47′	5.5	20′	80	8...
Algol (α)		EV	03h 08.2m	+40°57′	2.1↔3.4	2.867d		
NGC-1245		⊙	03h 14.6m	+47°14′	6.9	20′	40	11...
NGC-1275		#	03h 19.7m	+41°31′	13.0	0.7′x0.6′		
GK		N	03h 31.2m	+43°54′	14.0	Irr.		
Zeta (ζ)		★²	03h 54.2m	+31°53′	3.0,9.5	12.9″		
IC 2003		■	03h 56.4m	+33°53′	12.0	5″		18.0
NGC-1499		☐E	04h 04.3m	+36°25′	14.0?	145′x40′		
NGC-1528		⊙	04h 15.2m	+51°15′	6.0	25′	80	8...

★²	*Double Star*
EV	*Eclipsing Variable*
N	*Nova*
⊙	*Open Cluster*
■	*Planetary Nebula*
☐E	*Emission Nebula*
0	*Elliptical Galaxy*
#	*Peculiar Galaxy*

N★ = number of stars, Mag.★ = magnitude range of cluster or magnitude of central star, (...) indicates many fainter.


5h
4h
3h
2h
1h
+60°
+60°
CAMELOPARDALIS
IC 1805
IC 1848
M-103
NGC-957
NGC-869
NGC-884
CASSIOPEIA
γ
+50°
+50°
M-76
φ
NGC-1528
λ
Per OB-3
α
τ
θ
μ
υ
δ
ψ
σ
NGC-1245
ANDROMEDA
ϰ
GK
ν
M-34
+40°
+40°
NGC-1275
β
ε
ω
π
ϱ
NGC-1023
16
NGC-1499
ξ
IC 2003
TRIANGULUM
ζ
ο
+30°
+30°
TAURUS
Pleiades
ARIES
4h
3h

planetary data january 1984


Venus
Saturn
S
W
E
N
Jupiter
15th
Mercury
Mars
9th
21st
Uranus
Neptune

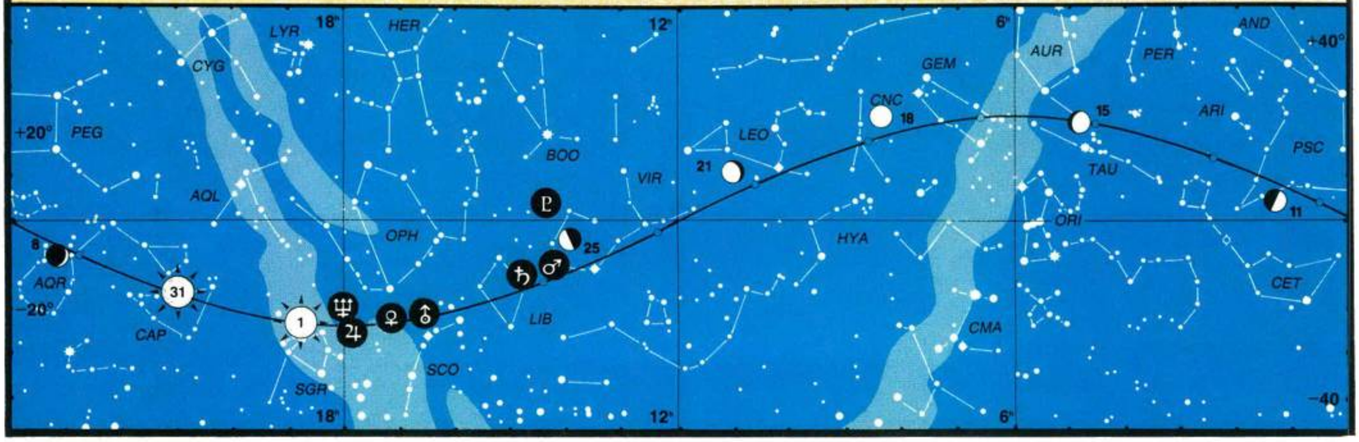
		Date	Mag.	Angular Size	% Illum.	Distance (AU) from: Earth	Sun	Longitude: Heliocentric	Ecliptic	R.A. (2000.0)	Dec.
Sun		1	−26.8	32.6′	—	0.98	—	—	279°45.3′	18h 43.4m	−23°04.1′
		15	−26.8	32.6′	—	0.98	—	—	294°01.5′	19h 44.6m	−21°16.2′
		31	−26.8	32.5′	—	0.99	—	—	310°18.0′	20h 51.9m	−17°36.3′
Mercury	☿	1	+4.6	10.0″	1%	0.67	0.31	277°39.0′	103°16.8′	18h 35.6m	−20°30.8′
		15	+0.1	7.7″	45%	0.87	0.38	271°10.4′	175°31.8′	18h 07.0m	−20°59.2′
		31	−0.2	5.9″	77%	1.15	0.45	286°55.2′	229°40.9′	19h 16.4m	−22°21.4′
Venus	♀	1	−4.1	15.2″	74%	1.10	0.72	239°26.2′	178°41.5′	15h 53.7m	−18°03.5′
		15	−4.1	14.0″	78%	1.19	0.72	256°23.1′	201°18.5′	17h 04.5m	−21°07.9′
		31	−4.0	13.0″	82%	1.29	0.72	275°55.6′	226°59.1′	18h 28.6m	−22°20.2′
Mars	♂	15	+1.0	6.3″	91%	1.47	1.66	211°28.9′	175°55.7′	14h 02.4m	−10°40.2′
Jupiter	♃	15	−1.8	32.0″	100%	6.16	5.28	268°31.9′	264°30.0′	17h 56.6m	−23°08.1′
Saturn	♄	15	+0.6	16.3″	100%	10.14	9.84	224°30.8′	219°38.6′	14h 53.8m	−14°11.2′
Uranus	⛢	15	+5.7	3.6″	100%	19.71	18.99	251°22.2′	249°53.8′	16h 42.5m	−22°11.5′
Neptune	♆	15	+8.0	2.2″	100%	31.16	30.26	269°22.8′	269°06.3′	18h 00.4m	−22°16.8′
Pluto	♇	15	+13.8	0.1″	100%	29.96	29.85	211°29.5′	210°03.9′	14h 23.2m	+ 3°34.8′

universal time

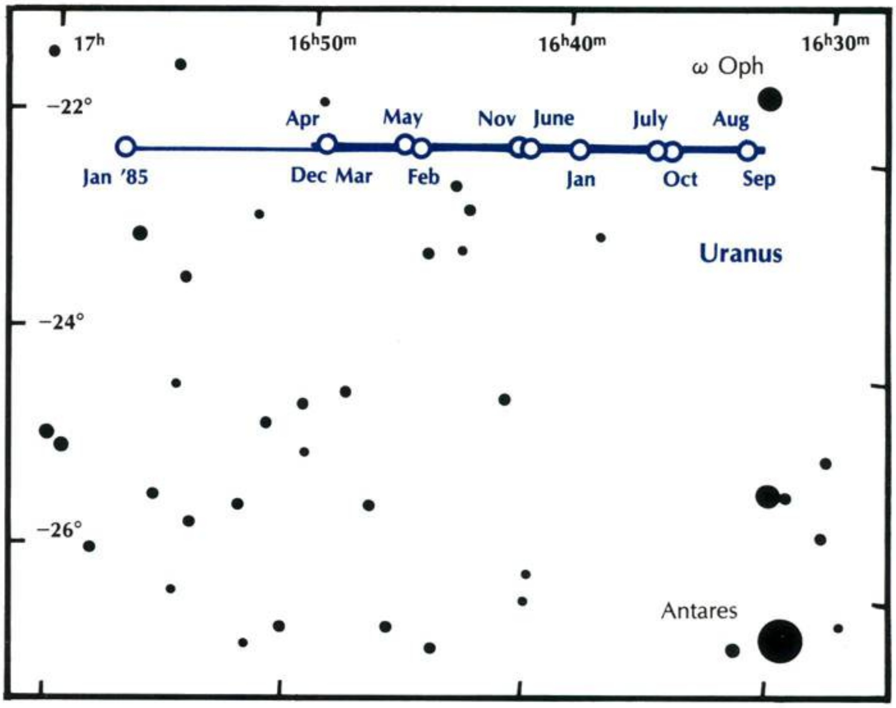
Astronomers the world over use an unambiguous system of time reckoning — Universal Time (UT) — based on a 24 hour clock. Times in The Backyard Astronomer are UT unless otherwise noted. To convert UT into your local standard time, subtract the following number of hours for each time zone: EST, 5; CST, 6; MST, 7; PST, 8; Alaska and Hawaii, 10. For example, if an event is to happen at 03:00 hours UT on February 2, then EST for the event is 10 p.m., February 1. Likewise, 03:00 UT on March 5 becomes, in PST, 7 p.m, March 4.

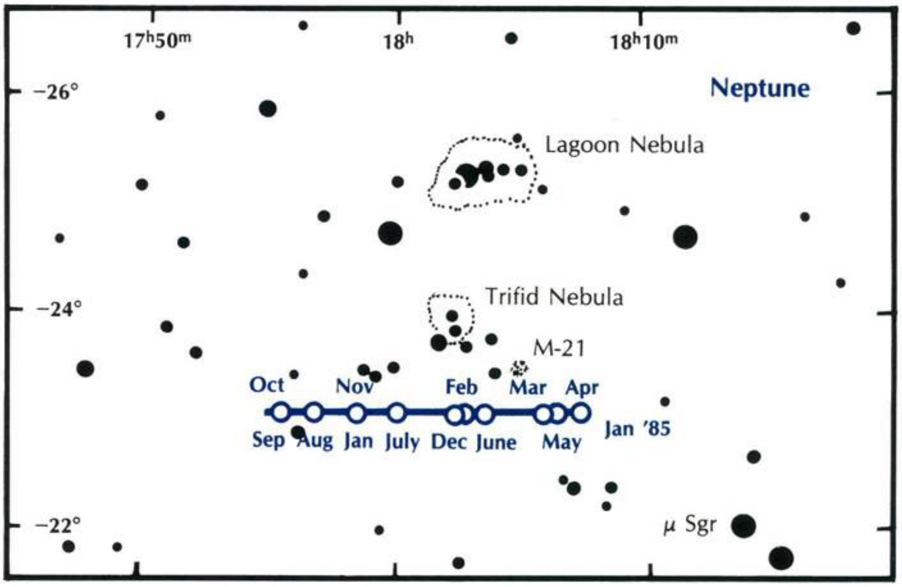
moon data

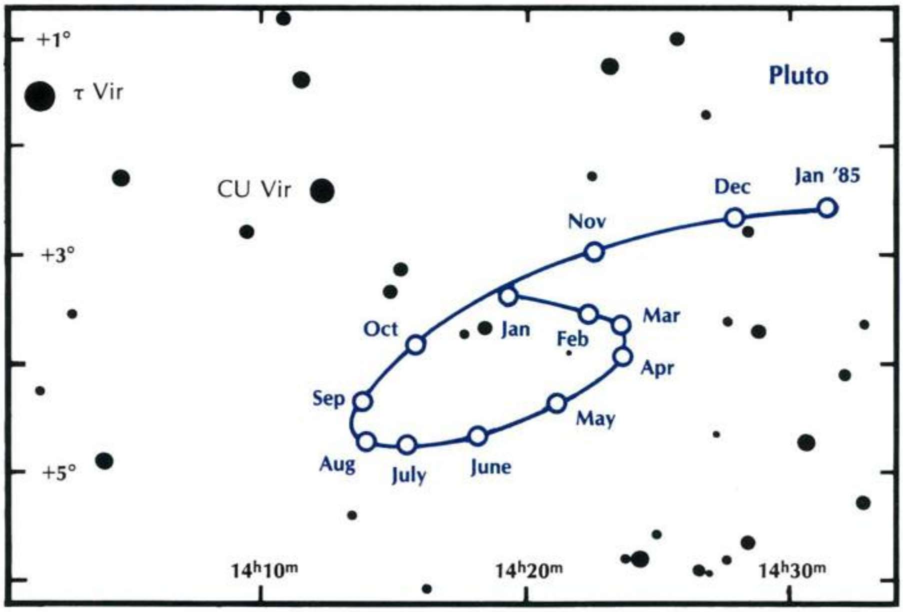
New Moon............January 3 at 5:16
First Quarter..........January 11 at 9:48
Full Moon............January 18 at 14:05
Last Quarter..........January 25 at 4:48
New Moon..........February 1 at 23:46
First Quarter.........February 10 at 4:00
Apogee: January 7 at 20:08...405,613 km.
Perigee: January 19 at 21:38...359,559 km.


LYR
18h
HER
12h
6h
AUR
AND
+40°
CYG
GEM
PER
+20°
PEG
CNC
18
15
ARI
LEO
BOO
PSC
TAU
VIR
21
AQL
11
OPH
25
HYA
ORI
8
AQR
−20°
31
CET
1
LIB
CAP
CMA
SCO
SGR
18h
12h
6h
−40

The positions of Uranus, Neptune, and Pluto for 1984 are given in the diagrams at right. The circles show the positions on the first of each month; the epoch of the coordinates is 2000.0. The Uranus chart has north at top (for use with binoculars); the charts for Neptune and Pluto have south at top to match telescopic views.


Uranus
17h
16h50m
16h40m
16h30m
−22°
−24°
−26°
ω Oph
Antares
Apr
May
Nov
June
July
Aug
Jan '85
Dec Mar
Feb
Jan
Oct
Sep


Neptune
17h50m
18h
18h10m
−26°
−24°
−22°
Lagoon Nebula
Trifid Nebula
M-21
μ Sgr
Oct
Nov
Feb
Mar
Apr
Sep
Aug
Jan
July
Dec
June
May
Jan '85


Pluto
+1°
+3°
+5°
τ Vir
CU Vir
Jan '85
Dec
Nov
Jan
Feb
Mar
Apr
May
June
July
Aug
Sep
Oct
14h10m
14h20m
14h30m

Mercury

At inferior conjunction on December 31st, Mercury will move quickly into the morning sky, where it will reach greatest western elongation on January 22nd.

Although Mercury pops into view during the first week of January, it won't be a good telescopic target until around the 10th, when it attains an elevation of at least 6°, 45 minutes before sunrise. Peak elevation (8°) comes on the 17th, and Mercury will remain in view until almost the middle of February — although it sinks below 6° elevation on January 28th.

This elongation isn't 1984's best — that will come in the evening sky in late March and early April — but it is the best *morning* elongation until that of September 14th.

Venus

Venus is losing altitude steadily in the morning sky — about 10° over the course of the month. Telescopically, it is also less interesting as its disk rounds out more and more and shrinks in size.

But this month Venus offers several fine conjunctions that more than make up for the lackluster appearance of the planet itself: On the 10th, Venus will pass 1° 50′ north of Uranus (conjunction: 12:37 UT). On the 25th, it will pass 47′ north of M-20 (the Trifid Nebula) and 1′ 31″ north of Neptune (23:15 and 23:21 UT). Finally, it will overtake Jupiter and pass 51″ north of it on the 27th (1:44 UT).

All of these pairings will give striking views in a telescope and promise excellent astrophotographic opportunities. (For more on conjunctions, see below under Jupiter and Neptune.)

totality ending for epsilon aurigae

The eclipsing binary Epsilon (ε) Aurigae has been at minimum light since December 1982. According to predictions, this "total stellar eclipse" will last until January 16, 1984. The star will then begin its return to full light, which it should reach by June 1984. (See "Mystery Star," in the August 1983 issue and last month's Close-up on Auriga.)

Anyone interested in observing this rare event — the eclipses occur at 27-year intervals — should compare Epsilon's brightness once a week relative to its neighbors Zeta (ζ), at 3.8 magnitude, and Eta (η), at 3.2 magnitude. In eclipse Epsilon is at 3.8 magnitude, but starting in January, you ought to see it begin to change. By early summer, it will have returned to its normal 3.0 magnitude brightness.

Left: Using Polachrome slide film (ASA 20), George Schelling took this photo of the waxing gibbous Moon with a ¼-second exposure at f/16 using a 4-inch Maksutov scope. Right: Jack Marling's portrait of the Eta Carinae Nebula wins this month's "Best Astro-Photo" award. He used 100 ASA film, a 200mm f/4 lens, and a 30-minute exposure.

Earth

Planet Earth reaches perihelion at 22h UT on January 3rd. We will then be 0.98238 astronomical units (146.96 million kilometers) from the Sun.

Mars

Mars rises about five hours before the Sun, which places it well up in the southern sky as dawn approaches. As seen in a telescope during January, Mars' apparent disk will increase in size by 23% — from 5.8'' of arc to 7.1''. The summer solstice for the martian northern hemisphere occurs in the middle of January.

Asteroids

1 Ceres (magnitude 8.8) is moving eastward in Aquarius. Its positions:

9th: 22h 39m 14s, −18° 03.6′
19th: 22h 52m 25s, −16° 30.7′

Ceres sets around 8 p.m. local time in mid-January.

2 Pallas (10.5) also has an eastward motion, which is taking it out of Aquila into Delphinus. Its positions:

9th: 20h 19m 35s, +0° 04.5′
19th: 20h 32m 46s, +0° 14.8′

Pallas sets about 6:30 p.m. local time on January 15th; it is in conjunction on February 6th.

3 Juno (8.5) is moving northeastward in Cetus. Its positions:

9th: 2h 17m 55s, −3° 12.7′
19th: 2h 29m 14s, −1° 28.8′

Juno transits around 7 p.m. local time at mid-month.

4 Vesta (6.9) is moving westward in Taurus near the Hyades Cluster. Its positions:

9th: 4h 56m 23s, +19° 25.4′
19th: 4h 50m 50s, +19° 49.6′

Vesta transits at about 9 p.m. local time on the 15th.

To facilitate plotting their positions on a star atlas, all asteroid coordinates are for the epoch 2000.0.

Jupiter

Jupiter was in conjunction with the Sun on December 14th, and normally wouldn't be worth turning your scope on for several weeks yet. But the giant planet will take part in two conjunctions (besides the one with Venus, mentioned above): At 17:23 UT on the 19th, it will pass 52′ of arc south of Neptune, and a day later — at 16:07 UT on the 20th — it will pass to the south of the center of the Trifid Nebula.

Jupiter's disk will be 32.1'' of arc across and at −1.8 magnitude; Neptune's will be 2.2'' and +8.0 magnitude. The nebula will be a dim greenish blob of light 18′ of arc across and at 9th magnitude.

Saturn

Saturn has now risen high enough so that telescopic observers don't have to peer through thick layers of hazy air in their efforts to see crisp definition of the rings and subtle banding on the planet itself. In fact, by dawn on the 31st, Saturn has transited the meridian.

The northern surface of the rings is tipped about 20° to your line of sight, and the Cassini division between the A and B rings is distinct. Can you pick up the much narrower and more elusive Encke division in the A ring? Or trace the dim smudge of the C (crepe) ring as it crosses the ball of the planet?

Uranus

Venus passes Uranus on the 10th (see above under Venus) — this is probably the easiest way to locate the planet. Uranus has a 3.6'' of arc disk at +5.7 magnitude.

Neptune

As with Uranus, the best way to locate the planet is to look for its conjunction with a brighter planet, such as Jupiter on the 19th or Venus on the 27th. Neptune also spends January close to the Trifid Nebula (M-20) in Sagittarius. It passes 45′ north of that object on the 25th at 19:42 UT.

Meteors

The big display this month is the Quadrantid shower, which peaks on the 4th — see the Gazer's Gazette feature on page 75 for all the details on how to observe and what you'll see.

elongations of mercury & venus — 1984

	Date	Altitude	Azimuth	Type & Extent of Elongation
Mercury	Jan. 22	8°	127°	West (morning sky) 24°
	Apr. 3	10°	282°	East (evening sky) 19°
	May 19	2°	79°	West (morning sky) 26°
	Aug. 1	3°	277°	East (evening sky) 27°
	Sep. 14	8°	83°	West (morning sky) 18°
	Nov. 25	4°	232°	East (evening sky) 22°
Venus	(no elongations all year; superior conjunction June 15)			

Altitudes and azimuths are given for 45 minutes after sunset (eastern elongations) or 45 minutes before sunrise (western elongations) as seen by an observer at 40° north latitude. In other latitudes the figures will vary slightly. North = azimuth 0° or 360°, east = 90°, south = 180°, and west = 270°.

Experience the Thrill of Deep-Sky Observing with

THE CAMBRIDGE DEEP-SKY ALBUM

by Jack Newton and Philip Teece

The Cambridge Deep-Sky Album
Jack Newton
Philip Teece
15 MINS.
DATE FEB. 4 '83
SUBJECT
M42 THE ORION NEBULA.
VIEW FROM THIS SIDE
North
M8

M8 The Lagoon Nebula
NGC 6523
Diffuse nebula in Sagittarius
RA 18h 02m
Dec −24° 23'
Mag 6.0

Imagine having a powerful telescope at your command, sweeping the skies in search of distant galaxies and nebulae, searching out the secrets of the heavens. **The Cambridge Deep-Sky Album** brings you all this and more — limited only by your imagination. Through the magic of modern astrophotography, you'll observe the delicate blue in the arms of spiral galaxies, the stunning deep red of glowing hydrogen nebulae, and the silvery glitter of star clusters strewn across the sky.

The Cambridge Deep-Sky Album is also a valuable companion for serious observers. Use it to plan observing sessions, or take it with you to the telescope. Its 136 color plates — shot by Jack Newton with his 16" reflector on cold-camera chilled Ektachrome 400 film — were made with the same exposure and are reproduced at the same scale for intercomparison. The description accompanying each plate gives every observer the background necessary to appreciate the true grandeur of celestial wonders seen in the eyepiece.

- **136 beautiful images — all in color**
- **authoritative text with each plate**
- **includes galaxies, nebulae, and star clusters**
- **each object identified by M- and NGC- numbers**
- **each image enlarged to uniform scale and orientation**

THE CAMBRIDGE DEEP-SKY ALBUM

only $19.95

Foreign orders add $1.50.

Send me____copy(ies) of **THE CAMBRIDGE DEEP-SKY ALBUM.**
Enclosed is my check for $________.

Name

Address

City State Zip

AB-11-3

To order, send this coupon or a copy to AstroMedia Order Dept., P.O. Box 92788, Milwaukee, WI 53202 — or use the handy AstroMedia order form bound into this magazine.

Columbia
ENGLE-TRULY
Columbia
YOUNG-CRIPPEN
APPROACH AND LANDING TEST
HAISE-FULLERTON
ENGLE-TRULY
Enterprise
SPACE SHUTTLE

NASA Emblems

from ASTRONOMY

Manufactured by
the Official NASA Supplier

Display these historic full-color patches in frames or wear them on a jacket or shirt — either way you'll be proud to show them.

SPACE SHUTTLE

***Space Shuttle** (SS4), 4"*
***Space Shuttle Columbia** (COL), 4"*
***Space Shuttle Approach & Landing** (SSAL), 4"*
***Columbia Engle-Truly** (STS2), 4"*
$4.95 each. Set of 4 Space Shuttle — $12.95

SKYLAB

Skylab 1** (SL1), **4", 2** (SL2), **4"
3** (SL3), **4", Skylab USA** (SL), **4",
$4.95 each. Set of 4 Skylab — $12.95

SKYLAB I
CONRAD-KERWIN-WEITZ
BEAN GARRIOTT LOUSMA
SKYLAB II
SKYLAB
CARR-GIBSON-POGUE
Skylab
UNITED STATES OF AMERICA

APOLLO MISSION

Apollo 1** (A1), **7** (A7), **8** (A8), **9** (A9), **10** (A10), **11** (A11), **12** (A12), **13** (A13), **14** (A14), **15** (A15), **16** (A16), **17** (A17), **All 4", $4.95 each.
Apollo/Soyuz** (A/S), **4" ($4.95), Apollo "A" Mission** (AA), **3" ($3.49).
Set of 14 Apollo — $39.95

ESA

Spacelab** (ESA1), **4", Ariane ESA** (ESA2), **4"
Spacelab NASA/ESA oval** (ESA3), **5¾"x3½" — $5.49 each.
Set of 3 ESA — $11.50

PLUS

First Lunar Landing** (LL), **4",
Project Viking** (VIK), **4" — $4.95 each. NASA extended vector** (NASA 1), **3" — $3.49

WHITE GRISSOM CHAFFEE
APOLLO 1
SCHIRRA
VII
BORMAN LOVELL ANDERS
SCOTT SCHWEICKART
McDIVITT
APOLLO IX
APOLLO
APOLLO 11
APOLLO XII
APOLLO XIII
SCIENTIA
APOLLO 16
APOLLO
APOLLO XVII
APOLLO/SOYUZ
APOLLO
NASA
spacelab
esa
NASA
ariane
esa
SPACELAB MISSION 1
NASA
esa
NASA
FIRST LUNAR LANDING
1969
UNITED STATES OF AMERICA
PROJECT VIKING
MISSION TO MARS

To order, specify patch name and code or set name on the AstroMedia order form bound into this magazine or send to AstroMedia Corp., Order Dept., P.O. Box 92788, Milwaukee, WI 53202.

SUPERSTAR

RENOWNED CELESTRON OPTICS
GUARANTEED 25 YEARS

HIGH TRANSMISSION COATINGS
FOR MORE BRIGHTNESS

8 X 50 CONVERTIBLE
FINDERSCOPE,
FAST, POWERFUL

Mars

M16 Eagle Nebula

BYERS SIDEREAL WORM DRIVE
FOR OUTSTANDING ACCURACY
(PAT. PENDING)

Orion Nebula

M13

26mm MULTI-COATED
PLÖSSL OCULAR FOR BRIGHT,
CRISP IMAGES

DELUXE LATITUDE ADJUSTER

Total Lunar Eclipse

M33 Spiral Galaxy

The World-Class Super C8—Now At Your Celestron Dealer.

200mm clear aperture, 2000mm effective focal length—in a personal, portable package weighing just 23 pounds, measuring just 17 inches. Fully camera adaptable, f/10 speed, and 791 times the light gathering ability of the human eye. Hand-figured, Celestron Certified optics, and a 25 year limited warranty. Available in your choice of Celestron orange or striking black. The latest generation of the world's best selling modern telescope is available now. Call or contact your Celestron Dealer for a thorough demonstration of this remarkable instrument.

Price increase February 1, 1984!

CELESTRON®
PRECISION OPTICS

For Dealer Locations, Catalogs, Information, Technical Data Sheets

CALL FREE 1-800-421-1526

(Mon-Fri; 8-4:00 Pacific Time; continental USA only)

CELESTRON INTERNATIONAL, P.O. Box 3578B12, 2835 Columbia St., Torrance CA 90503 (213) 328-9560